POWER

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Japan

THE Twentieth-Century man sits in the security of his modern home and reads of the struggle of his race through all the errors and perils of the prehistoric ages. Seared by or engulfed in seething cauldrons and eruptions of the still unstable earth; frozen by recurring glacial periods when the warmth of the sun died out and the polar ice crept down on a seemingly interminable winter; engulfed by great deluges, as when the waters of the Atlantic poured into the valley of the Mediterranean; the weaponless prey of monstrous animals; the wholesale victim of pestilence that he knew not how to avoid or combat, and the famine that his limited powers of production and distribution made inevitable with failing crops.

And he glories in the victory that his race has won over the land and sea, its growing mastery of disease and hunger and deprivation, and its subjection of the forces of nature to the use of man.

His greatest enemy has come to be man himself. His police and military forces, his courts and prisons, his aggressive and defensive industrial combinations and counter combinations are made necessary by the criminal or selfish injustice of other men. His greatest catastrophes are due to the abuse of his own devices or the mismanagement or failure of his own work.

And then of a sudden comes an upheaval like that in Japan when the solid earth itself runs riot and nature seems to be in an hysterical frenzy. The rock-built places of accustomed security become the centers of danger. The sea rushes into the mêlée, and fire, flood and heaving earth join in the pandemonium of destruction.

It is not many years ago that ruined Tokio and Yokohama would have lain for weeks in their misery before news of their misfortune reached the rest of the world. It is only recently that the unafflicted nations have had the means to speed food and succor to such unfortunates. Now the news is flashed around the world in a day, sympathetic governments and an ever-ready Red Cross Association dispatch their speediest messengers with substantial relief and the wealth, and brains and experience of the civilized world are concentrated upon the task of mitigating the disaster and relieving the suffering that it has produced.

Out of such a catastrophe comes an overpowering sense of the littleness and the mutual dependence of man; the deeper meaning of a universal brotherhood. It is a time when every heart should be touched with human sympathy and a generous impulse should convert it into yen.

F. R. Low

Recording Hydraulic-Turbine Governor Operation with an Oscillograph*

HOW a record of turbine speed gate movement and penstock pressure were recorded simultaneously with an oscillograph. A second article will deal with the test results and conclusions.

THE City of Baltimore receives a considerable part of its power supply from the hydro-electric plant of the Pennsylvania Water & Power Co. at Holtwood, Pa. This plant is paralleled with two large steam plants in Baltimore, located at Westport and Pratt Streets. During high flow in the Susquehanna River, the hydro-electric plant is operated wide open for about fourteen hours a day and the steam turbines carry all the swings, while their governors control the frequency completely. During low flow on the other hand, arrangement is made for the steam plants to carry the base of the load, while the hydraulic plant fills in the peak of the load curve and is supposed to carry the main swings of the load. During such times and also particularly at night time during high river flow, when only one or two steam turbines have been in parallel with the hydro-electric plant for protection, difficulty has been experienced in making the Holtwood plant take its proper share of the system load fluctuations, and this required at times carrying more load on the steam units in service than the system load would normally justify. To determine the cause of this it was decided to make a series of tests on the hydraulic governors to determine their actions on load swings and whether these governors possibly were less sensitive and responded to such swings more slowly than the steam governors. The oscillograph was selected as the best available device to obtain the information, and special means were involved for obtaining the records of the governor operation. The oscillograph permitted the simultaneous registration of three phenomena, and as these were selected the speed of the turbine, the gate opening and as the third phenomenon either the hydraulic pressure in the pit or the electrical load.

To obtain a record of the turbine's speed, a small series-wound direct-current 220-volt ¾-hp. motor was used as a generator and belted to the governor end of the countershaft by a strip of 1-in. heavy cotton tape carefully sewed so as to form a smooth joint (see Fig. 1). The field of this machine was separately excited from the direct-current lighting system with a 250-watt 220-volt lamp in series with the field coils to limit the current to approximately one ampere. The generator with this constant value of excitation developed a voltage directly proportional to its speed. Because of small irregularities of the commutator the current record was not perfectly smooth, and an inductance was inserted in the armature circuit. This sufficed to cut down the irregularities and yet did not introduce any appreciable lag in the records of speed changes.

A record of the gate opening was secured by using a length of No. 12 "Caledo" resistance wire, mounted parallel to the gate-operating cylinder, and a sliding contact provided which was attached to the piston crosshead as in Fig. 2. A current of 3.7 amperes taken from the direct-current lighting system was passed through this resistance wire and connections made so that the vibrator on the oscillograph received an increasing voltage drop as the piston moved toward the open position.

A large pressure gage with a scale 0 to 60 lb. was connected to the wheel pit by a ½-in. pipe to obtain a record of the pressure, and the moving element of the gage was equipped with a small sliding rheostat designed to have a minimum amount of friction, Fig. 3. Connections were made to give deflections on the oscillograph starting from zero at atmospheric pressure and increasing as the pressure rose.

It might be mentioned here that there is some doubt concerning the absolute value of the pressures recorded since the gage was operated by air pressure, although the variations in pressure as measured from normal are probably sufficiently accurate for use. This uncertainty comes from the fact that the pressure gage was located on the generator floor some distance above the wheel pit, and the pressure recorded depended on how high the water stood in the connecting pipe. Before the tests as much of the water as possible was blown out of this pipe by compressed air and all joints made tight.

The cushioning action of the air in the connecting pipe may have affected the record slightly, but as the pressure rise requires an appreciable time (approximately three seconds), the error here introduced is not thought to be serious. For calculated values of pressures see the last paragraph.

The current or load record was obtained by inserting a shunt in the current transformer secondary circuit of the generator under test.

*The data in this article were supplied by A. F. Bang, superintendent of operation, Pennsylvania Water & Power Company, under whose directions the tests were made.

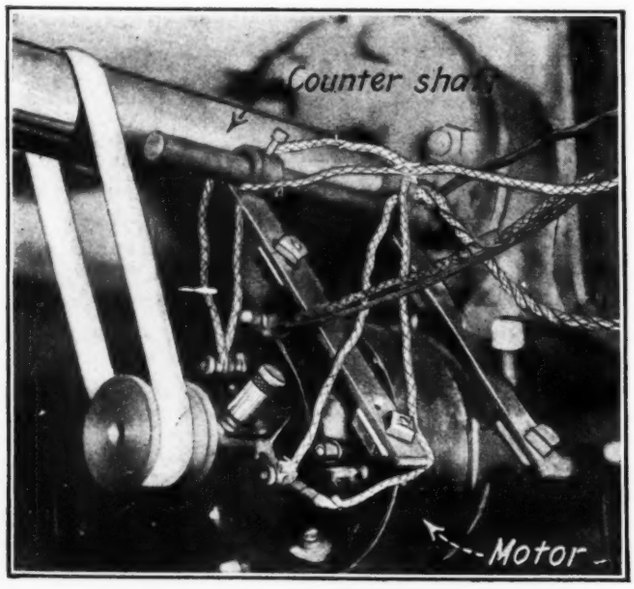

FIG. 1—SERIES MOTOR WAS BELTED TO GOVERNOR COUNTER SHAFT AND OPERATED AS A SEPARATELY EXCITED SHUNT GENERATOR TO OBTAIN A RECORD OF SPEED CHANGE ON THE OSCILLOGRAPH

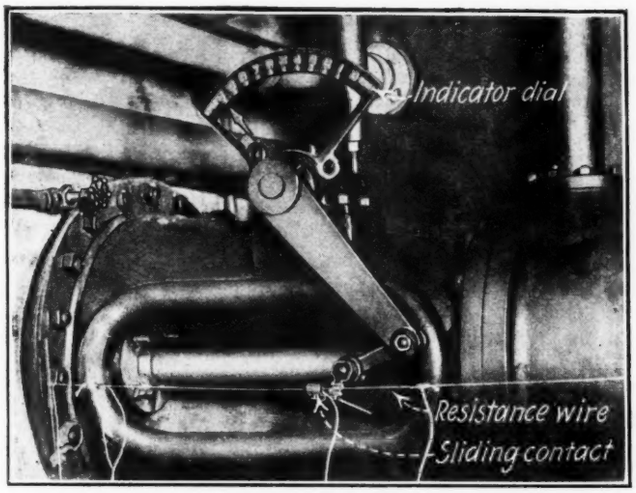

FIG. 2—SLIDING CONTACT, CONNECTED TO GATE OPERATING PISTON CROSSHEAD, MOVES ON RESISTANCE WIRE TO GIVE A RECORD OF GATE MOVEMENT ON THE OSCILLOGRAPH

A separate source of load was required for these tests because it was not considered desirable from an operating viewpoint to throw the unit directly on to the line in the "load on" tests. A water rheostat was first tried, but as the water heated up the load became so unsteady as to cause the unit to hunt badly and make it difficult to obtain consistent test results.

It was then decided to use the sleet-bus connection. This consisted in taking one of the Baltimore circuits out of service, shorting and grounding all three phases at the substation end and connecting the generator directly to the power house end of the line. With 10,000 volts on the uni this gave a load of about 5,000 kw. at 72 per cent power factor. For the heavy load changes the sleet bus was not sufficient and the water box was paralleled with it, and fairly good results obtained, as the part of the load passing through the water-box was small. For all tests the oscillograph was located in the testing laboratory and two pairs of special leads run from the operating tunnel. For the current record a spare pair of wires in the inter-communicating telephone system was used.

Immediately before each test the various devices were calibrated with the oscillograph; the governor generator by putting the unit on hand control and running idle at speeds considerably above and below normal, the gate by successively running the sliding contact to the points corresponding to the open and closed position, and the gage by moving the pointer manually from 0 to 20 lb. pressure.

During the test observers were stationed at the operating cylinder, the tachometer near the governor, the benchboard and the speed-recording generator, and readings taken immediately before, during and after each load change. This was a help in checking up the oscillograph calibrations. To insure against the belt slipping on the speed-recording generator, immediately before each test belt dressing was applied to the countershaft, generator pulley and the belt itself.

In order to notify observers when the test would occur, a large electric bell was placed in the operating tunnel. This bell could be operated either by a push button or by the shutter-opening device on the oscillograph. One minute before each test a signal was given by the push button. This signal meant that the observers were to prepare to record the visual swings. At the instant the shutter on the oscillograph opened and exposed the film, the bell started to ring and continued until the shutter closed. This aided the observers in determining the exact time of test and period during which the phenomena were being recorded. If any fault in the recording apparatus developed during this period, it could be reported and a re-test made.

For a few of the earlier tests on the governors the pressure rise or fall in the wheel pit during a sudden gate movement was recorded on the oscillograms. However, after several observations it was decided that the change in pressure was so small that for the later tests, this record was discontinued and in its place was substituted the current value on the unit under test. The observed pressure rise for a 5,000-kw. load thrown off was 2 lb. per sq.in., a maximum increase in head of 4.6 ft., which is so small that it can practically be neglected.

To further prove that the change in pit pressure, was of no great importance in this low-head plant, calculations were made using R. D. Johnson's formula for maximum rise of pressure in feet above normal (page 757 in the discussion of paper No. 1349, American Society of Civil Engineers) which deals with "pressures in penstocks caused by the gradual closing of turbine gates." Also, see *Power*, page 770, Nov. 14, 1922. The calculations gave somewhat higher values than those recorded on the oscillograph, but of the same order. For example, as previously mentioned, the rise in wheel-pit pressure recorded was 4.65 ft. when a 5,000-kw. load was thrown off the unit. According to the calculations made the rise was 6.74 ft., and with a 10,000 kw. load taken off, a pressure rise of 7.38 ft. was obtained by calculation. The normal head on the plant is about 60 ft. It is true that an increase in suction on the draft-tube side of the wheel will also occur and adds to the total pressure acting on the wheel when the gates are closed. While this suction was not measured, calculations indicate that it is of the same order as the pressure rise in the pit, and it is therefore evident that dangerous pressure rises due to the gates closing need not be feared at Holtwood.

FIG. 3—PRESSURE GAGE EQUIPPED WITH SLIDING-CONTACT RHEOSTAT FOR RECORDING CHANGE IN PENSTOCK PRESSURE ON THE OSCILLOGRAPH

Effective B.t.u. and Cost Determine Value of Coal

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CONSIDERATION has been directed recently to a classification of coal that could be used to guide buyers in making selection of their supplies. The fundamental reason for classification is to insure the marketing of a superior product as against an inferior or to enable the buyer and user to select the best or the most economical product.

In one form or another the main use of coal is to produce heat. It is, of course, true as a general principle that for fuel purposes the coal containing the greatest amount of effective heat is the best to use unless the item of cost overcomes the advantage of high B.t.u. There are, however, some requirements that demand coal of a special character. Anthracite, for example, owing to its peculiar nature, is in demand because it makes no smoke, is hard and slow burning, and while it is of less heating power than bituminous coal, many people prefer it notwithstanding. The same is true in a measure of semi-bituminous coal and coke for that matter. These demands for peculiarity of character take precedence over other features of value. A user of anthracite will pay a higher price for it and get less heat for his money than he could from a good bituminous coal, but for special reasons he will use the anthracite. Size of the coal also has an influence in selection. For stoker use a small size is essential, and screenings, even if of lower heating power than lump coal, are better suited to the purpose.

NEW method proposed for comparing heat values effective to the furnace of different coals. Cost delivered and effects of moisture and ash are considered. Using the best coal under consideration as a standard, other grades of coal are compared and their relative values as fuel determined.

It is apparent, therefore, that in any scheme of determining value to govern economical purchase, these demands for special character must be considered. On this basis some people will use anthracite, others semi-bituminous or coke, while the majority will use bituminous coal, and some will want a particular size, so no one scheme of classification on a basis of cost of heating power can be comprehensive enough to embrace these conflicting requirements. Therefore, when the user has decided on the character he will use, be it anthracite, bituminous or any other kind, and the most suitable size, he is interested in getting the best value obtainable in each grade, and what follows is a scheme that will enable him to do so because it may be applied to any variety of coal.

In this consideration the first step is the matter of price or cost. It is not sufficient to base purchase on the price at the mine, because mine price is only one item of cost. It is at the point of delivery that cost should be based. Thus mine price plus freight is the true cost of coal. It is the delivered cost that is the basis of what follows:

Having defined the standard basis for price, it is in order to take up the subject of heat value. Formerly, the laboratory determining of B.t.u. was accepted without question as giving the proper measure of heat value of the fuel as applying to furnace conditions. This practice has been a failure, and many people, with good reason, have felt that the calorimeter B.t.u. does not cover the whole subject of quality and that results in service do not always conform to it.

The determination of the heating power under proper conditions by calorimeter is an accurate and exact process, as not only is all the heat in the coal developed, but it is all recovered in the water that surrounds the bomb in which the coal is burned, and this heat is accurately measured. In other words, the calorimeter process is perfect, which is not true of the fires in which the coal is put to a practical use.

It is therefore apparent that what is needed is a B.t.u. value that fits the furnace condition, a practical B.t.u. value as distinct from the theoretical laboratory result. Such a B.t.u. value has been devised and is known as the effective B.t.u.,[1] as being effective in combustion in the furnace. The constituents of the coal that are involved in the determination of the effective B.t.u. value are ash and moisture. Moisture in coal has a negative value. It not only displaces a portion of the fuel, causing lower B.t.u., but its presence causes a further loss, as it must be heated to the evaporating point, then evaporated into steam, and the steam superheated to the temperature of the chimney. For the heating, one B.t.u. is required per pound of moisture for each degree Fahrenheit rise in temperature. For evaporation, 970 B.t.u. are required per pound, and for superheating, one-half of a B.t.u. is used for a pound of steam for each degree rise in temperature. Therefore, low-moisture coal, even if the B.t.u. is the same, is to be preferred. The heat required to dispose of moisture is given in detail as follows:

	B.t.u. Absorbed by 1 Lb. of Moisture
To heat from 70 to 212 deg.	142
To evaporate	970
To superheat the resulting steam from 212 to 500 deg. temperature of the chimney.	144
Total	1,256

This is the amount of heat required to dispose of a full pound of moisture. A pound of coal, of course, contains only a fraction of a pound of moisture, so the 1,256 multiplied by the fraction of a pound, gives the B.t.u. lost.

Ash, like moisture, not only displaces a like amount of fuel, but has a further harmful influence, as it

[1] This term was introduced to the public at the meeting of the International Railway Fuel Association in Chicago in May, 1922, and is discussed on pages 181 to 189 of the Proceedings of the Fourteenth Annual Convention.

interferes with combustion, so that full development of the heat that is in the coal cannot be realized. The harm the ash does varies with the kind of furnace in which the coal is burned. Tests made by the United States Geological Survey at the St. Louis Exposition showed, as an average, that for each 1 per cent excess of ash the value of the coal was reduced by 1½ per cent. These tests were with a hand-fired furnace. One of the largest electric companies made exhaustive tests[2] on stokers and found that for each 1 per cent excess ash the fuel value of the coal was reduced by 1 per cent.

In addition to interference with combustion the presence of ash is a further cause of loss of heat, as ashes and refuse removed from the furnace or discharged by the stoker always contain some coke or coal, and the higher the ash in the coal the larger this loss. With carefully operated stokers refuse is at least 20 per cent fuel as an average. With hand fires it is usually greater, about 30 per cent. On this basis one coal must be referred to another which is taken as a standard for comparison, as no coal carries zero moisture or ash, so the standard taken must be the best coal that is available for use and the value of the poorer coal made relative to it. The formulas for determining the effective B.t.u. are as follows:

FORMULAS FOR DETERMINING EFFECTIVE B.T.U.

Moisture:

Per cent excess moisture × 1,256 = *B.t.u. loss* (1)

Ash:

For hand fires, (per cent excess ash × 1.5*)* × *B.t.u. by calorimeter* = *B.t.u. loss* (2)

For stokers, per cent excess ash × *B.t.u. by calorimeter* = *B.t.u. loss* (3)

Ashpit loss:

Per cent excess ash × 0.3 *for hand fires and* 0.2 *for stokers* = *carbon in refuse* (4)

Carbon in refuse × 14,500 *B.t.u. in a pound of carbon* = *B.t.u. loss* (5)

Total heat lost:

Loss by moisture + *loss by excess ash* + *loss in ashpit refuse* = *total B.t.u. lost* (6)

Effective B.t.u.:

B.t.u. by calorimeter — *total B.t.u. loss* = *effective B.t.u.* (7)

To illustrate the application of these corrections, two compositions are given in Table I. The best coal is taken as the standard of comparison, showing what the poorer is worth against the better; with freight rates, and mine price of coal *A* assumed, the question is what should be paid for coal *B* at the mine to insure getting the same amount of value from it for a dollar as could be had with coal *A* costing $3 at the mine and $3 for freight, as against the poorer coal with $2 freight. The calculations applied to coal *B* to determine its effective B.t.u. and its value as related to the better coal are as follows:

TABLE I—RELATIVE VALUES OF TWO COALS IN HAND-FIRED FURNACE

		Coal A	Coal B
1.	Moisture, per cent	5	15
2.	Moisture, excess over coal *A*, per cent		10
3.	Ash in moist coal, per cent	7.50	15
4.	Ash in dry coal, per cent	7.89	17.64
5.	Ash in dry coal, excess over coal *A*, per cent		9.75
6.	B.t.u. by calorimeter in laboratory	13,125	10,875
7.	B.t.u. effective in the furnace	13,125	8,735
8.	Relative value, ratio of Item No. 7	1.000	0.665
9.	Mine price to place each coal on same basis of value	$3.00	$2.00
10.	Freight	$3.00	$2.00
11.	Cost at point of delivery to place each coal on same basis of value	$6.00	$4.00

Loss due to excess moisture:

1,256 × 0.10 = 125.60 = 126 *B.t.u.*

Combustion loss due to excess ash:

0.0975 × 1.5 *applying to hand fires* = 0.14625

0.14625 × 10,875 = 1,590 *B.t.u.*

Loss due to coke in the ashpit refuse:

0.0975 × 0.3 = 0.02925 *of a pound of carbon*

0.02925 × 14,500 *B.t.u. in a pound of carbon* = 424 *B.t.u.*

Total B.t.u. loss:

126 + 1,590 + 424 = 2,140 *B.t.u.*

Effective B.t.u.:

10,875 *calorimeter B.t.u.* — 2,140 = 8,735 *B.t.u.*

Relative value:

8,735 *B.t.u. of coal B* ÷ 13,125 *B.t.u. of coal A* = 0.665

CAREFUL ANALYSIS NECESSARY

Unless a competitive proposition of this kind is analyzed carefully, it is difficult to arrive at a just comparison. A little difference in mine price or freight rate usually decides purchases, when if the matter be properly analyzed, very different conclusions might often be arrived at. Many buyers are influenced by a few cents less for poorer coal, when the value of the better is often as much $1 per ton over the cheaper coal.

The average buyer being offered coal *B* of 10,875 B.t.u. costing $2 at the mine, with freight of $2, against 13,125 B.t.u. for coal *A* at a mine price of $3 and $3 for freight, might conclude naturally that the difference in freight and mine price would easily overcome the advantage of the higher B.t.u. of the better coal, with a good margin to spare. Coal *A* being taken as the standard for comparison, mine price and freight being known, the question is what *B* is worth at the mine. As the cost at the point of delivery for *A* is $6 and as the value of *B* is 66.5 per cent of *A*, the cost of coal *B* at the point of delivery should be 66.5 per cent of $6 = $3.99, or for even figures, $4. As the freight is $2, there is only $2 left for the mine price.

Table No. 2 shows how this scheme applies to an important coal-producing territory embracing eight fields in which the quality of each field is sufficiently uniform to allow of its being dealt with as a unit. It is assumed that everyone using coal desires to purchase the best quality if it is not too expensive. Therefore any user buying in this territory would prefer coal from field No. 1 unless its cost was out of proportion to its value. Assuming that 1¼-in. screenings from field No. 1 are offered at $2.15 at the mine, with $1.95 freight and a delivered cost of $4.10, while screenings from field No. 4 have a freight rate of $1.65. To determine the mine price that should be paid, multiplying $4.10 by the relative value 0.761, it is found that the delivered cost of coal No. 4 should be $3.12, out of which $1.65 freight must be taken, leaving $1.47 available for the mine price. Thus coal No. 1 at $2.15 and No. 4 at $1.47 at the mines give the same number of B.t.u. for a dollar.

To reverse the problem, assume mine-run coal from field No. 3 at $3 at the mine with $1.85 freight, costing $4.85 at the point of delivery, and that the question is what price a buyer could afford to pay for mine run from field No. 1. This is determined by dividing $4.85, cost of coal from field No. 3, by its relative value 0.817, which gives a delivered value for field No. 1 of $5.94,

[2]See "Journal, Western Society of Engineers," Vol. XI, p. 554.

and this figure less $1.95 freight, gives a mine price of $3.99.

Any engineer or coal buyer can make his own table of relative values for his territory if sufficient analytical data are available, and calculate the relative values for the different qualities. It is then a simple matter by the use of the relative value factor to govern his purchase. The correction used in Table II is applied to stoker conditions. In the case of coal used in hand-fired furnaces the relative values would be lower than those given in this table.

Good Coal Requires Less Draft

While the foregoing covers the subject of the relative value of coal, it does not take into consideration the management of its combustion in the furnace, which is of importance, because good coal may give no better results than poor coal if improperly handled. In general, less grate surface and draft are required with good than with poor coal. This may mean a less number of boilers in use and more in reserve for repairs and cleaning.

In many instances the plant operating program is based on the use of poor coal on account of a lower mine price or freight, or a combination of both. Under such conditions a habit is established of using a certain number of boilers, and when better coal is tried, it is used in the same number of boilers with the result that as more heat is developed than with the poorer coal, the tendency is to make too much steam. To prevent safety valves from blowing, thin or short fires are carried, so that the extra heat in the better coal is wasted up the chimney in excess air. A few illustrations will serve to make this point clear.

In a large plant equipped with chain-grate stokers, at times both high and low B.t.u. coal were used. The complaint was that no better results were had from the better than from the poorer grade. The reason for this was that in both cases the same number of boilers were operated. It required a certain number of boilers and extent of grate area to carry the load with the poor coal, and when the good coal was put in, the same number of boilers were used. Owing to the short fires so much unnecessary air flowed into the furnace through the bare grate that the extra heat of the good coal was wasted up the chimney.

In a plant of two hand-fired boilers both were required to carry the load, using a low-grade coal on a short freight rate. A number of tests of a high-grade coal were made, using in each case both boilers, and the results were against the good coal. The owners were planning to enlarge the boiler house and install a third boiler when they had their attention called to the advisability of making another trial of the good coal, using only one boiler. This was done with the result that not only was the cost of producing steam reduced, but a boiler could be held in reserve for cleaning and repairs and the cost of additional building and boiler was saved.

In the case of a cement plant using coal in powdered form in rotary kilns, a trial of a better grade of coal was made, and it was reported that the coal was unsatisfactory because it made "too hot a fire." The reason was they fed the same amount of it as they did with the low B.t.u. coal, and of course made too much heat. The proper course in this case was to feed less coal.

Coal in a gas-producer plant was changed from a low grade high in ash to a better quality with low ash. It had been the practice to remove a certain number of wheelbarrows of ash each day, and this practice was continued with the better coal, with the result that not only was all the accumulated ash removed, but good fire as well. Complaint was made that the coal was not satisfactory because it "did not contain enough ash." Ash removal should have been revised to fit the better fuel.

In some instances it is a matter of using the damper to hold the fire, or a reduction in grate surface; in others, using fewer boilers. This tends, of course, to the carrying of hotter fires and to a somewhat greater destruction of furnace brickwork, but while this may result in a cost of cents for brick, it means a saving of dollars in coal.

TABLE II—DIFFERENT QUALITIES OF COAL PRODUCED IN EIGHT FIELDS OF A LARGE PRODUCING TERRITORY, WITH FIELD NO. 1 TAKEN AS BASIS TO WHICH THE OTHER FIELDS ARE COMPARED

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
				1¼-in. Screenings				
1. Moisture at loading	6.50	9.60	11.25	14.25	15.92	13.55	11.05	12.09
2. Moisture excess		3.10	4.75	7.75	9.42	7.05	4.55	5.59
3. Ash in moist coal	11.00	14.48	15.66	14.62	16.63	11.52	16.70	15.90
4. Ash in dry coal	11.66	16.02	17.64	17.05	19.78	13.32	18.77	18.42
5. Ash excess in dry coal		4.36	5.98	5.39	8.12	1.66	7.11	6.76
6. B.t.u. by calorimeter	12,169	11,008	10,023	10,400	9,560	10,865	10,447	10,369
7. B.t.u. effective in the furnace	12,169	10,330	9,147	9,264	8,372	10,536	9,389	9,353
8. Relative value, ratio item 7	1.000	0.849	0.752	0.761	0.689	0.866	0.772	0.769
				2-in. Screenings				
1. Moisture at loading	6.50	9.60	11.25	14.25	15.92	13.55	11.05	12.09
2. Moisture excess		3.10	4.75	7.75	9.42	7.05	4.55	5.59
3. Ash in moist coal	10.65	13.32	14.40	13.45	15.30	10.59	15.36	14.62
4. Ash in dry coal	11.50	14.73	16.22	15.68	18.19	12.25	17.26	16.63
5. Ash excess in dry coal		3.23	4.75	4.18	6.69	0.75	5.76	5.13
6. B.t.u. by calorimeter	12,213	11,177	10,627	10,266	9,748	11,000	10,640	10,554
7. B.t.u. effective in the furnace	12,213	10,663	9,890	9,589	8,736	10,801	9,762	9,690
8. Relative value, ratio item 7	1.000	0.873	0.810	0.785	0.715	0.884	0.799	0.794
				Prepared Sizes				
1. Moisture at loading	6.50	9.60	11.25	14.25	15.92	13.55	11.05	12.09
2. Moisture excess		3.10	4.75	7.75	9.42	7.05	4.55	5.59
3. Ash in moist coal	6.42	7.75	8.15	8.50	8.52	6.75	8.35	8.60
4. Ash in dry coal	6.85	8.57	9.18	9.91	10.13	7.81	8.94	9.25
5. Ash excess in dry coal		1.72	2.33	3.06	3.28	0.96	2.09	2.40
6. B.t.u. by calorimeter	12,847	11,984	11,526	10,969	10,709	11,556	11,654	11,488
7. B.t.u. effective in the furnace	12,847	11,676	11,113	10,425	10,121	11,321	11,277	11,055
8. Relative value, ratio item 7	1.000	0.909	0.865	0.811	0.788	0.881	0.878	0.860
				Mine-Run Coal				
1. Moisture at loading	6.50	9.60	11.25	14.25	15.92	13.55	11.05	12.09
2. Moisture excess		3.10	4.75	7.75	9.42	7.05	4.55	5.59
3. Ash in moist coal	7.10	9.05	10.79	10.56	10.53	7.85	12.05	12.17
4. Ash in dry coal	8.00	10.11	12.16	12.31	12.50	9.01	13.54	13.83
5. Ash excess in dry coal		2.11	4.16	4.31	4.50	1.01	5.54	5.85
6. B.t.u. by calorimeter	12,680	11,648	11,028	10,608	10,424	11,578	11,196	10,987
7. B.t.u. effective in the furnace	12,680	11,286	10,358	9,898	9,674	11,335	10,318	10,062
8. Relative value, ratio item 7	1.000	0.890	0.817	0.704	0.763	0.893	0.813	0.793

Strength of Used Elevator Cables*

By C. W. WILLITS

SOME engineers use a definite method in determining when a chain becomes dangerous. Links are punch marked at certain distances apart when the chain is new and when these punch marks have separated a specified distance, the chain is replaced. However, no definite method has ever been worked out by which the strength of an old cable could be estimated. This statement was verified by consulting practically every elevator company, cable manufacturer and editor of technical publications in the United States. It was also found that there were no experimental data that could be used as a guide to aid elevator inspectors in estimating the strength of cables being inspected. The purpose of this investigation was to obtain experimental data that would show the effect of wear on cables and to formulate a rule that could be used in determining by inspection the approximate tensile strength of old cables.

A cable wears while passing over a sheave and the wires become broken. In some cases the wires become corroded if they are not well lubricated. These are the three visible indications of weakness of a cable. Corrosion can be avoided, but wear and broken wires cannot be eliminated. Wear and the number of broken wires, however, can be reduced to a minimum by keeping the cable well lubricated with the proper lubricant and by using properly designed sheaves. The grooves in the sheave must have the proper profile, and they must be kept in good condition if the maximum service is to be obtained from the cables. Worn grooves have a very damaging effect upon cables.

Wires Weakened by Fatigue

Fatigue of the metal in the wires is probably an important weakening factor, especially in steel cables, but on account of the pliability of the metal in iron cables the effect is less noticeable. Cables are stressed by bending while passing over a sheave. Worn wires either fail by tension in that part of the cable opposite the line of contact, or they fail by buckling at the line of contact with the sheave. The wires may also fail in tension at the line of contact because of the pulling action of the sheave against the cables. All broken wires found during this investigation were worn on the outer surface of the strands. In some cases, where the specimen had been cut from near the fastening, one side of the cable was worn while on the opposite side the wires were in good condition. On these specimens only the worn wires were broken.

A cable is composed of strands, which are the fundamental units of construction. The wires of the strands are twisted together according to a definite geometrical arrangement. One wire is placed at the center of the strand, and the other wires are wound around this center wire in successive concentric rings. In a 6x19 cable the center wire is surrounded by two successive concentric rings of wires, the first ring consisting of six and the outside ring of twelve wires, making a total of nineteen wires in the strand, Fig. 1. There are six strands in the cable and the diameter of the inclosing circle of the six strands is the size. When the size is $\frac{5}{8}$-in., the size and construction are briefly specified as 6x19x$\frac{5}{8}$ cable.

The specimens tested during this investigation were cut from 6x19x$\frac{5}{8}$ cables and were the product of four different manufacturers. All except four of the cable specimens were cut from various parts of condemned cables that had been used on elevators in the Union Central Life Insurance Building. The approximate mileage of each cable was 25,000 and they had been in service about 2$\frac{1}{2}$ years.

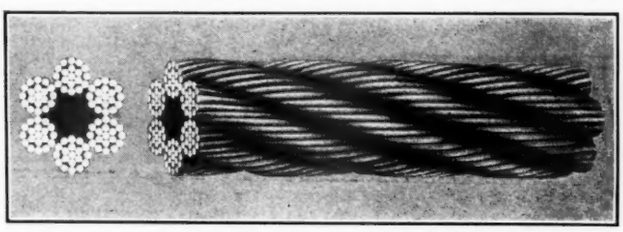


FIG. 1—SECTION OF 6x19x$\frac{5}{8}$ ELEVATOR CABLE

Six hoisting cables are used on each elevator. The weight of the car, hoisting cables and compensation is 4,500 lb., and the maximum carrying capacity of the elevator is 3,000 lb., making the dead load on the cables 7,500 lb. Tests were made on these elevators by C. B. Garrison, and it was found that the load on the cables was increased about 50 per cent when the elevator was brought to a sudden stop. Thus the maximum total tensile stress on the six cables was 1,250 lb. to 1,875 lb. per cable.

Standard sockets were used on all cable specimens. Babbitt was used in the sockets for ten of the tests, and zinc spelter was used for all other tests. In preparing for socketing, the cable was first wound for about 1$\frac{1}{2}$ in. with friction tape at a distance equal to the length of the socket from the end of the specimen. Then the hemp core was removed and the wires were unraveled. The wires were scraped and then cleaned in gasoline, after which they were dipped in a solution of hydrochloric acid. Then they were tinned by dipping in a ladle of molten socket metal. The sockets were drawn in place and heated with a

*The data in this article are from a thesis prepared by the author in part fulfillment of the requirements for the degree of mechanical engineer at the University of Cincinnati, 1923.

CAPTAIN M. W. McINTYRE, manager, and C. B. Garrison, chief engineer, of the Union Central Life Insurance Company's Building, Cincinnati, Ohio, have carried out a program of cable investigation extending over a period of ten years. See article, "Records of Elevator Cable Operation Show Wide Differences in Life of Cables," July 24 issue. The investigation recorded in the present article was promoted by them and is a continuation of their program of cable research and gives the results of over 150 tests made on worn cables and 43 tests made on wire taken from these cables. All material and special apparatus used in making tests were furnished by the Union Central Life Insurance Co., of Cincinnati.

blow-torch before the metal was poured around the wires. When zinc was used the unwound wires were left straight, but when babbitt was used the wires were turned in toward the center of the socket. The lengths of the cable specimens tested were 21, 12½ and 2½ ft., and the length of the wire specimens was about 1½ feet.

A 100,000-lb. Riehlé tension-and-compression machine in the mechanical engineering laboratories of the university was used to test the cable specimens. The 2½-ft. specimens were held in the head and platen by means of the standard wedge-shaped jaws that are used in testing round steel. The jaws, however, did not come in contact with the cable; they were drawn home, and the sockets rested on them, leaving the cable free between the sockets. The 12½- and 21-ft. specimens were passed around a 34-in. sheave, and the sockets rested on the channel beam which was bolted to the head of the machine, as in Fig. 2.

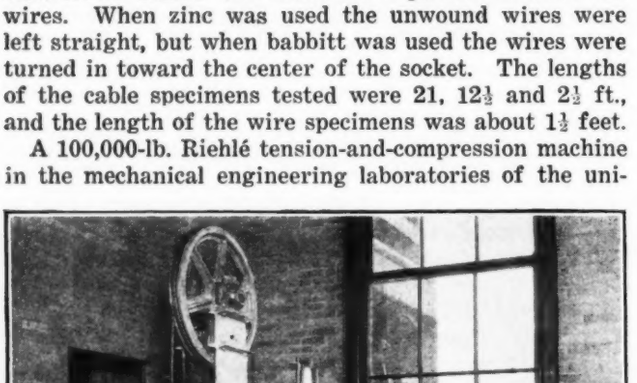


FIG. 2—ONE METHOD USED IN TESTING WORN ELEVATOR CABLES

Load was thrown on the cable gradually up to about 1,500 lb., and then the head speed was increased to about 6 in. per min. until the load was approximately 8,000 lb. The machine was then run at a head speed of 0.2 in. per min. until a fracture of one or more strands occurred. Fig. 3 shows typical fractures that occurred in the cable specimens. The numbers attached to the cables refer to the test numbers on the data sheet, Table I. The specimen marked *X* had the outer wires worn off 50 per cent by filing; two strands failed at the socket under a stress of 13,150 pounds.

The wire specimens were taken from cable specimens that had been broken and tested in a 20,000-lb. Olsen wire-testing machine. The wire specimens were about 1½ ft. long and were held in the standard wedge-shaped jaws that are used in testing wire. The load was applied gradually by a hand operated crank.

Collection of Data

The primary object in collecting data was to determine, if possible, the effect of wear on the tensile strength of the type of cable under investigation. Inasmuch as the specimens were cut from well-lubricated, uncorroded cables, an excellent opportunity was afforded for making a comparative study of the effects of fatigue upon the wires in the cable. Wire specimens were taken from the cables where they were badly worn, where they were slightly worn and where they had not come in contact with the sheave at all.

Data were also collected to determine the effect of broken wires on the tensile strength of the cable. This was done by cutting a certain number of adjacent wires in each successive strand at a specified distance between the cuts. By this method it was possible to approximate the effect of broken wires at different intervals of distance by varying the number of wires cut and the distance between the cuts.

In recording the smallest cross-sectional dimension of the worn wires of the cable specimens, the mean of several measurements was taken. In the case of the wire tests the smallest cross-sectional dimension was measured as near the fracture as would give a fair dimension of the worn part of the wire. All measurements of wires were made with a micrometer. There is a greater range of variation in the test results of cable than in most materials of construction, therefore a larger number of tests are necessary in order to obtain fair averages.

Conclusions

Several conclusions were drawn from the results of the tests performed during this investigation:

1. The effect of fatigue on the tensile strength of the metal in 6x19x⅝ iron elevator cable is comparatively small when the smallest cross-sectional dimension of the wires is 0.034 in. or larger and the cable is well lubricated and runs on a sheave 30 in. in diameter or larger.

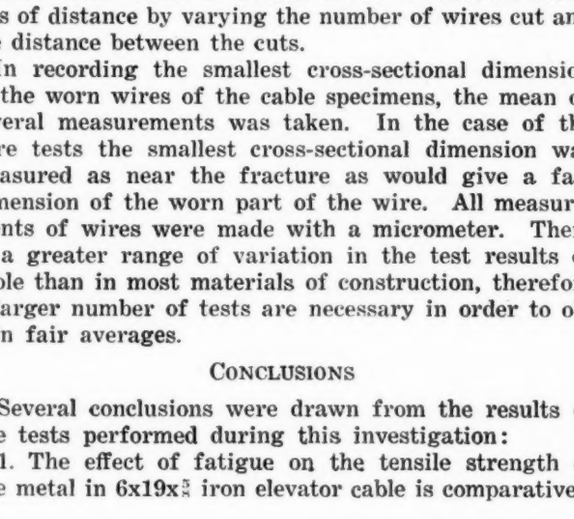


FIG. 3—SOME TYPICAL CABLE FRACTURES

2. Broken wires have not occurred in cables where they cannot be detected. This conclusion is drawn from the results of inspections made during this investigation and from similar inspections made by C. B. Gar-

rison during the last ten years. These inspections consisted in unwinding the outer wires of the strands of condemned cable and examining the condition of the inside wires. These statements refer to 1-to-1 traction elevator machines having 34- and 36-in. sheaves, such as are installed in the Union Central Life Insurance Building, and have no reference to 2-to-1 roped or traction machines equipped with so-called V-grooved sheaves or drum-type machines, either of which would influence the cable life.

3. The stress in a 6x19x$\frac{5}{8}$ iron cable is not greatly increased when it passes over a 34-in. sheave. Only two of the specimens tested during this investigation broke at or near the sheave. It is evident, however, that some of the individual wires become highly stressed because of the bending of the cable over a sheave.

4. The strength of a cable is directly proportional to the sum of the areas of the unbroken wires in a 6-in. length.

5. The effective area of a worn cable is approximately equal to the original area minus the reduction of area by abrasion, minus the sum of the areas of the broken wires within a distance of 6 in. This distance over which wires should be counted in determining the reduction of area of a cable is of empirical derivation based on results of tests. The curves, Fig. 4, show that the exact distance would vary with the conditions of the cable. The curves also show that 6 in. is a safe distance to use in calculating the strength of a cable.

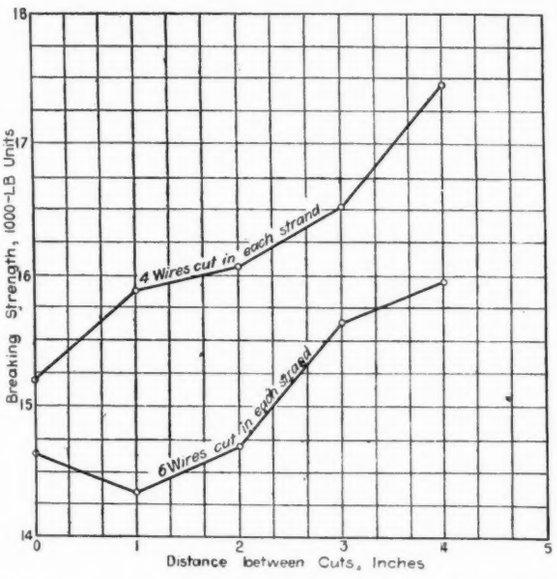


FIG. 4—CURVES SHOW EFFECTS OF BROKEN WIRES IN CABLE STRANDS

Under ideal testing conditions the curves, Fig. 4, would probably be straight lines. The curves obtained from the mean values of test results indicate the location and direction of ideal curves. As previously stated, the distance would be a variable, varying with the condition of the cable. The distance six inches, as was chosen, is larger than the curves would indicate, but was selected to include the extreme case. From observations of fractures of the strands it was found that the strands broke in such a way that the broken ends of the wires were almost even in every case. This showed that the friction between the wires was great enough to cause a broken wire to weaken the cable for a distance only

TABLE I—TEST DATA ON WORN ELEVATOR CABLES

Cable Test No.	Manufacturer	Length of Specimen, Ft.	Number of Wires Cut in Each Strand	Dist. Between Cuts, In.	Dimension D, Fig. 5, of Worn Wires, In.	Number of Wires, Broken in Service, in 6 In.	Total Number of Wires Broken and Cut, in 6 In.	Test Strength, Lb.	Computed Strength by Use of Chart, Lb.	Number of Strands Failed: In Body	Number of Strands Failed: At Socket
ZINC SOCKET META											
1	B	2.5	4	1	0.041	0	24	11,380	10,000	1	
2	B	2.5	4	1	0.041	0	24	8,400	10,000	4	
3	B	2.5	4	2	0.041	0	16	11,660	10,800	1	
4	B	2.5	4	2	0.041	0	16	12,040	10,800	1	
5	B	2.5	3	2	0.041	0	12	10,650	11,200	1	
6	B	2.5	3	2	0.041	0	12	10,870	11,200		
7[2]	B	2.5			0.041	0	38	8,170	8,400		
8[2]	B	2.5			0.041	0	38	7,860	8,400		
9[1]	B	2.5	0		0.022	0	0	9,950	9,000	2	
10[1]	B	2.5	0		0.022	0	0	10,910	9,000		
11[1]	B	2.5	0		0.015	0	0	7,060	.....	2	
12[1]	B	2.5	0		0.015	0	0	7,280			
13	C	2.5	2	2	0.041	0	8	9,360	11,000	2	
14	C	2.5	2	2	0.041	0	8	9,420	11,000		
15[1]	C	2.5	0		0.030	0	0	8,170	10,400	1	
16[3]	C	2.5			0.041	0	19	8,510	10,000		
21[4]	A	12.5	4	2	0.035	5	21	14,910	14,500		
22[4]	A	12.5	4	3	0.035	5	17	11,400	15,100		
23[4]	A	12.5	6	0	0.041	0	36	13,200	13,000		
24[1]	A	2.5	0		0.022	0	0	13,150	13,400	2	
BABBITT SOCKET METAL											
25	A	12.5	0		0.035	6	6	15,420	17,400		3
26	A	12.5	0		0.036	5	5	15,060	17,700		3
27	A	12.5	0		0.038	0	0	17,550	18,800		4
28	A	12.5	0		0.035	7	7	16,700	17,000		2
29[4]	A	12.5	0		0.040	0	0	14,260	18,900		
30	B	12.5	0		0.036	5	5	11,370	11,500		6
31	B	12.5	0		0.036	5	5	11,310	11,500		4
32	B	12.5	0		0.036	5	5	11,140	11,500		4
33	B	12.5	0		0.041	0	0	10,650	12,600		2
34[4]	B	12.5	0		0.036	5	5	9,360	11,500		
ZINC SOCKET METAL											
35	B	12.5	9	0	0.035	10	64	7,790	7,600	6	
36	B	12.5	0		0.041	0	0	12,640	12,600	6	
38	B	12.5	0		0.034	10	10	12,170	10,700	1	
39	B	12.5	0		0.041	0	0	12,490	12,600		6
42	B	12.5	0		0.036	8	8	12,460	11,200		6
43	B	12.5	0		0.036	8	8	12,240	11,200	6	
44	B	12.5	0		0.036	10	10	11,890	11,000		6
46	B	12.5	0		0.036	10	10	12,070	11,000		6
47	B	12.5	0		0.040	0	0	12,330	12,500		6
48	B	12.5	0		0.034	16	16	10,780	10,100		6
50	B	12.5	0		0.033	16	16	10,110	9,900		6
53	A	12.5	0		0.041	0	0	18,970	19,000	4	
54	A	12.5	0		0.034	7	7	16,080	16,600		2
56	A	12.5	0		0.037	3	3	17,720	18,000	2	
57	A	12.5	0		0.039	2	2	18,790	18,600	1	
58	A	12.5	0		0.037	4	4	17,300	17,900		2
59	A	12.5	0		0.035	7	7	16,630	16,800		3
60	A	12.5	0		0.035	7	7	16,510	16,800		1
61	A	12.5	0		0.035	9	9	17,800	16,500		4
62	A	12.5	0		0.035	8	8	18,250	16,800	1	
66	A	2.5	2	1	0.041	0	12	16,100	17,000	1	
67	A	2.5	2	1	0.035	3	15	16,500	15,500	1	
68	A	2.5	2	1	0.035	3	15	15,720	15,500	2	
70	A	12.5	2	1	0.034	6	18	15,330	15,000	2	
75	A	2.5	4	1	0.038	0	24	15,020	14,600	3	
76	A	12.5	4	1	0.041	0	24	17,390	15,000	3	
78	A	2.5	6	1	0.037	2	38	13,710	12,200	2	
79	A	21.0	6	1	0.041	0	36	15,050	13,000	2	
80	A	12.5	6	1	0.037	2	38	14,270	12,200	3	
81	A	2.5	2	2	0.036	0	8	17,730	17,000	2	
82	A	2.5	2	2	0.034	5	13	16,020	15,600	1	
86	A	2.5	4	2	0.036	2	18	16,000	15,300	2	
87	A	2.5	6	2	0.036	2	26	14,460	13,900	2	
89	A	2.5	2	3	0.036	2	8	17,180	17,000		
94	A	2.5	4	3	0.035	5	17	17,080	15,200	1	
95	A	12.5	4	3	0.034	7	19	15,970	14,600	2	
96	A	2.5	6	3	0.035	5	23	15,180	14,200	2	
97	A	12.5	6	3	0.034	10	28	16,580	13,000	2	
99	A	2.5	2	4	0.035	5	9	17,840	16,500		6
100	A	2.5	2	4	0.035	5	9	17,600	16,500		1
101	A	2.5	3	4	0.035	5	11	16,920	16,000		3
103	A	2.5	4	4	0.035	5	13	17,500	15,900	2	
104	A	2.5	6	4	0.035	5	17	15,590	15,200	3	

[1] Diameter of cable reduced by filing.
[2] Two whole strands were cut.
[3] One whole strand was cut.
[4] Wires pulled out of socket metal.

All specimens are from 6 x 19 x $\frac{5}{8}$-in. iron cables. Book rating of cables 12,000 lb. Original strength from test of unworn part of cables, *A*-19,000 lb.; *B*-12,600 lb. Test strength of *A* and *B* and book rating of *C* were used in computing strength of cables. Service of *A* and *B* hoisting; *C*, counterweight. Time in service approximately 2½ yr.; mileage approximately 25,000. Maximum load on cables in service, 1,870 lb. All specimens were cut from condemned passenger-elevator cables. Standard sockets were used with zinc spelter and wires broomed straight on all specimens except Nos. 25 to 34, where babbitt was used and the wires turned in.

equal to the pitch or lay of the wire in the strand.

A formula, $S = \frac{S'}{0.1504}\ (0.05544 + \frac{D}{0.41} - 0.00132\ N)$, was derived for determining the tensile strength of worn 6x9x$\frac{5}{8}$ elevator cables when the original strength in pounds is known. In this formula S is the tensile strength of a worn 6x19x$\frac{5}{8}$-in. iron elevator cable, S' is the tensile strength of the same cable when new, D is the smallest cross-section dimension in inches of the worn wires in the cable (see Fig. 5), and N is the number of broken wires within a lineal distance of 6 in. From Table I, showing 73 tests of over 150 made, it is evident that with the exception of where the cable failed at the socket, the results obtained with the formula are fairly consistent with the test values. The greatest difference between the calculated results and the test strength of the cable is found where the cable failed at the socket, in which case the test strength did not represent the tensile strength of the cable itself. A future article will give the derivation of the formula and an alignment chart based on it for calculating the strength of worn cable.

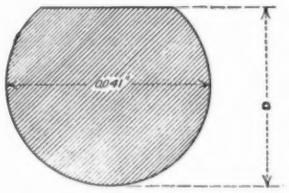


FIG. 5—DIMENSIONS OF WORN WIRE

Table III gives a comparison of the factor of safety specified in the A. S. M. E. "A Safety Code for Elevators," and the actual factor of safety of the cable tested during this investigation, at the time that they were condemned. The tests considered in this comparision are numbers 36 to 64 inclusive. These specimens were tested without wires being cut and were weakened only by service.

TABLE II—TEST DATA ON WIRES TAKEN FROM ELEVATOR CABLES

Wire Test No.[1]	Cable Test No.	Position of Wire in Strand	Dimension D, Fig. 5, of Worn Wire, In.	Area of Wire at Fracture, Sq.In.	Tensile Strength Lb.	Tensile Strength Lb. per Sq.In.
1	25	Outside	0.034	0.0011710	172	146,900
2	25	"	0.036	0.0012282	184	150,000
3	25	"	0.035	0.0012008	172	143,000
4	25	Inside	0.041	0.0013202	234	177,000
5	25	"	0.041	0.0013202	184	139,000
6	26	Outside	0.035	0.C012008	140	117,000
7	26	"	0.037	0.0012544	159	126,600
8	26	"	0.037	0.C012544	162	129,000
9	26	Inside	0.041	0.0013202	188	142,000
10	26	"	0.041	0.0013202	184	139,000
11	27	Outside	0.039	0.0012961	190	146,700
12	27	"	0.038	0.0012727	192	150,800
13	27	"	0.038	0.0012727	186	146,000
14	27	Inside	0.041	0.0013202	220	166,500
15	27	"	0.041	0.0013202	224	170,000
16	28	Outside	0.036	0.0012282	166	136,000
17	28	"	0.034	0.0011710	176	150,000
18	28	"	0.034	0.0011710	194	165,000
19	28	Inside	0.041	0.0013202	202	153,000
20	28	"	0.041	0.0013202	212	160,000
26	47	Outside	0.041	0.0013202	118	89,400
27	47	"	0.039	0.0012961	126	97,400
28	47	"	0.040	0.0013116	123	93,700
29	47	Inside	0.041	0.0013202	122	92,500
30	47	"	0.041	0.0013202	150	113,800
34	48	"	0.041	0.0013202	120	91,000
35	49	Outside	0.034	0.0011710	118	101,000
36	49	"	0.036	0.0012282	114	93,000

[1] Length of wire specimens, 18 inches.

The maximum values of the strengths represent more nearly the actual strength of the cable because in the case of the minimum values the cables broke at the socket, whereas, in the case of the maximum values the specimens broke in the body. If the minimum strengths were used to determine the strength of the cable, the socket efficiency, which is not known, would have to be considered.

An accident occurred in Cincinnati some months ago that shows the danger of not having a definite method in determining the strength of a cable; that is, a method that could be used not only by inspectors, but by anyone who was called upon to decide whether or not a cable was safe. An old 6x19x$\frac{5}{8}$ iron cable was tested and its strength was found to be over 10,000 lb. This same cable was then used on a hoist for elevating material and workmen. The diameter of the sheave was only 12 in., and after three days of service the cable broke under a load of about 1,500 lb. and caused serious injury to two workmen. Upon inspection after the accident it was found that there was a large number of breaks in the wire caused by bending over the small sheave. This is not the first time an accident has occurred from using a condemned elevator cable for some other purpose.

TABLE III—COMPARISON OF ALLOWABLE AND ACTUAL FACTORS OF SAFETY*

Cable Test No.	Manufacturer	Max. Test Strength of Unworn Cable	Max. Test Strength of Worn Cable	Min. Test Strength of Badly Worn Cable	Location of Fracture
36	B	12,640	.....	.....	In body
38	B	.....	12,170	.....	In body
50	B	.....	.....	10,110	At socket
53	A	18,970	.....	.....	In body
62	A	.....	18,250	.....	In body
54	A	.....	.....	16,080	At socket

Factor of Safety When Cables Were Condemned

Cable Test No.	Manufacturer	Using Max. Test Strength of Worn Cable	Using Min. Test Strength of Worn Cable	Factor of Safety Specified by A.S.M.E "Specified Code fo Elevators"
36	B	.....	.....	.....
38	B	9.72	.....	11
50	B	.....	8.1	11
53	A	.....	.....	.....
62	A	14.6	.....	11
54	A	.....	12.87	11

Cable Test No.	Manufacturer	Per Cent Reduction of Strength by Wear Using Max. Test Strength of Worn Cable	Per Cent Reduction of Strength by Wear Using Min. Test Strength of Worn Cable	Per Cent Reduction Allowed by "Safety Code for Elevators"
36	B	.....	.....	.....
38	B	3.7	.....	0
50	B	.....	20.0	0
53	A	.....	.....	.....
62	A	3.8	.....	13.3
54	A	.....	15.3	13.3

*Static load per cable, 1,250; rated speed of car, 700 ft. per minute.

The calculations necessary to employ in determining the amount of cooling water required for a Diesel are quite simple. As an example of the maximum amount that could be used, the intake water temperature at the jacket entrance can be taken as 90 deg. This is at least 10 deg. higher than normal, even with a cooling pond. The engine discharge water temperature can be taken as 140 deg. F., which is 20 deg. below the value most successfully used. Then the rise in temperature will be 50 deg.; consequently each pound of water will absorb 50 B.t.u. The water per hp.-hr. will be $\frac{3000}{50} = 60$ lb.

This expressed in the form of an equation appears as

$$W = \frac{XH}{100\ (t_1 - t_2)}$$ where

W = weight of water required per hp.-hr.
X = percentage of heat absorbed by the water.
H = total heat supplied to the engine.
t_1 = discharge water temperature deg. F.
t_2 = intake water temperature deg. F.

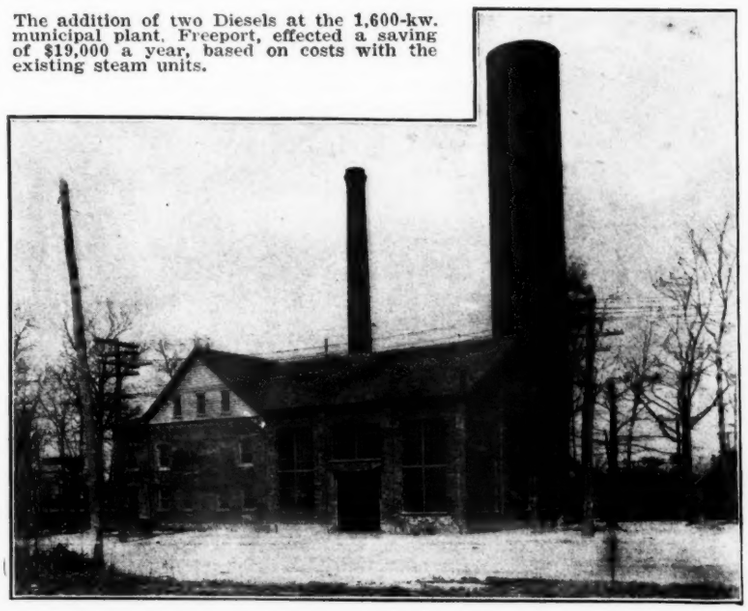
The inlet and discharge temperatures given may not check with those observed in any particular installation, nevertheless the temperature range is approximately correct; it is this factor that is important.

Oil Engines Reduce Power-Plant Costs

By L. H. MORRISON

THE failure of many municipal light plants is due to the type and condition of the station equipment. No doubt there are some instances of rank inefficiency in the station force or in the management, but the high cost of power in these plants usually may be traced to excessive fuel charges brought about by the inferior type of machinery in the plant.

The average municipal plant does not have, as a rule, a depreciation or obsolescence account to enable the machinery to be replaced when worn out or when the rising cost of fuel makes the operation of the units, even though mechanically in good condition, inadvisable. The consequence is that these plants are too often filled with machinery that should properly be junked and replaced by units of a more modern design. By following the lead of the management of privately owned plants who do not hesitate to discard machinery in order to reduce generating costs, the municipal plant has every chance to be a success.



The addition of two Diesels at the 1,600-kw. municipal plant, Freeport, effected a saving of $19,000 a year, based on costs with the existing steam units.

As an example of how a municipal plant overcame these difficulties of outgrown machinery and high fuel costs the history of the light and water department of Freeport, N. Y., may be cited.

Originally, this plant was installed for water-works service alone, but the growth of the village was such that a light plant was added, the machinery consisting of two horizontal tubular boilers, a small Corliss engine belted to a generator and duplex steam-driven water pumps. As the village increased in population, more generating equipment was installed until in 1919 there were four boilers, and three Corliss engines, totaling 875 horsepower.

During this period coal was procured at the then prevailing low rates, and as the machinery was in good condition the cost of generating electricity was low. However, these favorable conditions were all overturned by the high fuel prices that followed the outbreak of the war.

In 1920 the plant was taxed to its maximum capacity and additional equipment was imperative. In view of the fuel situation combined with the comparative low efficiency of small steam units, it was decided to install an oil engine. As a result of this decision a 500-hp. Busch-Sulzer type B Diesel direct-connected to a 312 kva. General Electric alternator was purchased. To accommodate this unit, the roof of one end of the engine room was raised to give the desired headroom. This engine was placed in service in May, 1921, and for twenty months operated continuously. During this time the engine received no bearing adjustment nor were any of the pistons pulled or cylinder heads removed. The engine was by no means able to carry the entire peak

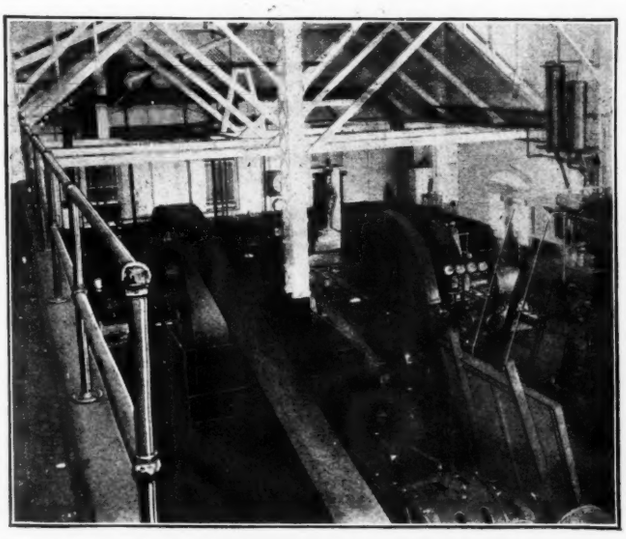


FIG. 1—STEAM ENGINES IN FREEPORT PLANT

FIG. 2—HAND-FIRED BOILERS

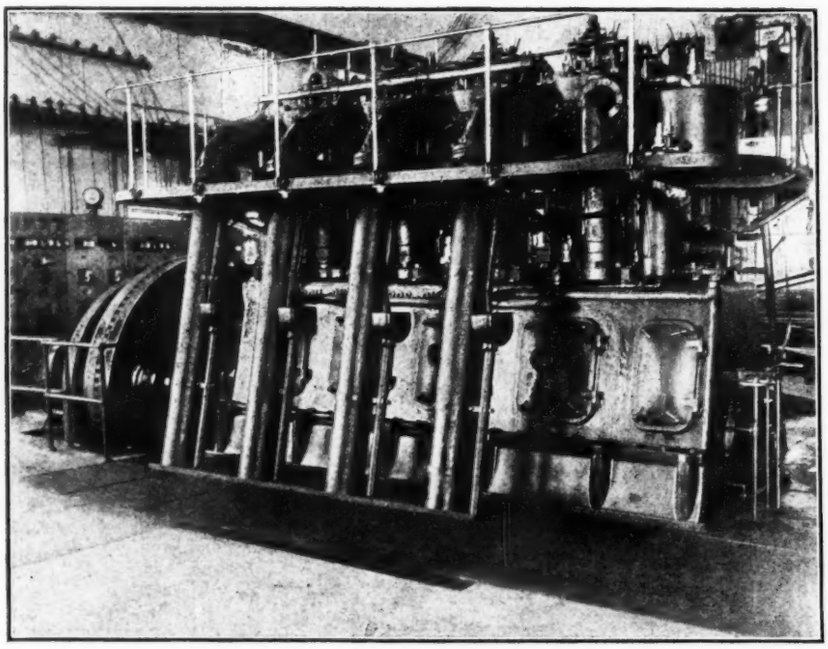


FIG. 3—500-HORSEPOWER DIESEL

load which occurred during the evening hours, and the steam plant was used to carry the excess load.

The growth in the plant output up to this time is shown in Table I, the data being the output in kilowatt-hours during the month of October for each year save those shown blank, for which no record exists.

TABLE I—KILOWATT-HOUR OUTPUT DURING OCTOBER

Year	Kw.-Hr.	Year	Kw.-Hr.	Year	Kw.-Hr.
1905	22,794	1911	.....	1917	111,851
1906	29,597	1912	.....	1918	103,006
1907	32,726	1913	.....	1919	131,322
1908	38,148	1914	92,899	1920	151,019
1909	42,061	1915	100,412	1921	193,839
1910	.....	1916	104,947	1922	242,303

The Diesel was installed by the builder's erector, who gave preliminary instructions to the plant's operating force. Neither the chief engineer nor the watch engineers had ever operated an oil engine, and the success experienced is evidence of the reliability and simplicity of this type of engine.

To enable the oil-engine plant to take more of the peak load, since the operating costs of the first Diesel were strikingly below those of the steam plant, in 1922 a 750-hp. Busch-Sulzer two-stroke-cycle Diesel direct connected to a G.-E. generator was installed.

To accommodate the 750-hp. unit, an addition to the engine room was necessary. This was made high enough to give the necessary head clearance for piston removal.

The outputs of the steam units and the Diesel engine from May 1, 1921, to January, 1923, is shown in Table II. It will be noticed that the Diesel delivered an average of 9.562 kw.-hr. per gal. of fuel oil, while the average for the steam plant was 7.242 lb. coal per kw.-hr. Since the steam units were not in constant operation, their fuel consumption was higher than would have been the case if in constant operation; for example, in May, 1921, when the coal per kilowatt-hour was 6.37 lb. In computing the saving by the Diesel engine this rate has been used.

If the steam plant alone had been in operation, the total plant output of 3,703,659 kw.-hr. would have required 10,559 tons of coal. The average coal price during this period was $7.75, making the probable total fuel cost for exclusive steam operation $81,832.25. The cost of coal and fuel oil was $49,788.83, making a saving over all steam operation of $32,043.42.

An examination of the savings possible by the elimination of the steam plant reveals that Diesels would have required a total of 387,412 gal. of fuel oil, costing $24,238.43, or a saving of $25,550.40 over the combination steam-Diesel operation. If overhead charges are assumed to be 15 per cent, the fuel saving alone would have taken care of the overhead charges of 1,000 kw. in additional Diesel units. At the present time the city is considering tenders on a second 750-kw. unit, the quotations on the engine, generator and exciter ranging from $43,000 to $63,000.

The simplicity of the oil-engine part of the plant is in marked contrast with the portion containing the steam machinery, which requires much in the way of accessories occupying large floor space per horsepower. All the apparatus required by the oil engines, such as oil filters, oil pumps, etc., is either incorporated in the engines or located close to the units. The exhaust piping is placed outside the building and, being provided with exhaust pots, has no objectional features such as noise

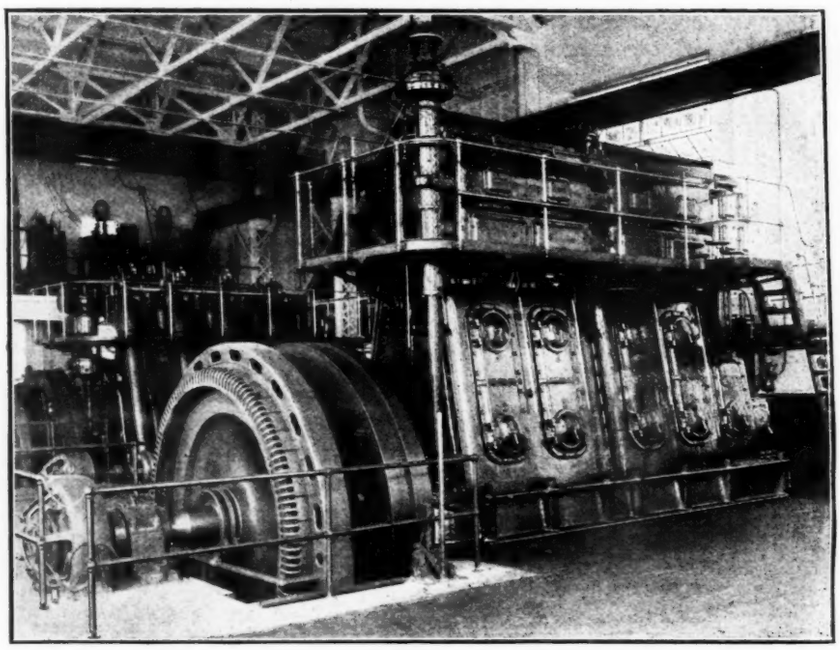


FIG. 4—VIEW OF THE 750-HORSEPOWER AND THE 500-HORSEPOWER UNITS

or odor. Practically the only noise in the plant is from the scavenging intake tunnel of the 750-hp. unit. This was made of timber and, because of the vibration set up by the air pulsations, will be replaced by a concrete tunnel.

The 750-hp. two-stroke-cycle engine operates as satisfactorily as does the 500-hp. four-stroke-cycle unit. No difficulty has been experienced with the cooling-water systems and the lubricating-oil consumption has been very low on both machines.

TABLE II—KILOWATT-HOUR OUTPUT

Month	Kw.-Hr. by Steam	Lb. Coal	Coal per Kw.-Hr.	Kw.-Hr. by Diesel	Gal. Oil	Kw.-Hr per Gal.
1921						
May	82,575	525,978	6.37	38,410	5,000	7.68
June	23,317	288,156	10.55	91,070	10,068	9.04
July	30,981	278,946	9.00	94,610	10,242	9.24
August	35,680	324,440	9.09	107,430	11,513	9.33
September	45,321	338,472	7.71	110,320	11,480	9.61
October	81,139	503,460	6.20	112,700	11,898	9.47
November	85,888	495,072	5.76	123,500	12,916	9.56
December	112,997	569,664	5.04	128,050	13,170	9.72
1922						
January	84,402	573,930	6.80	124,570	12,606	9.88
February	64,363	467,838	7.27	108,180	11,050	9.88
March	68,056	482,344	7.09	125,450	12,805	9.79
April	60,317	465,264	7.71	115,730	11,875	9.75
May	44,503	378,000	8.49	118,810	12,460	9.53
June	46,854	428,400	9.14	114,350	12,070	9.47
July	43,710	467,100	10.27	123,030	12,900	9.76
August	61,421	573,700	8.69	123,360	13,010	9.48
September	72,384	534,312	7.38	120,980	12,621	9.59
October	102,223	764,856	7.48	140,080	14,337	9.77
November	106,236	775,422	7.30	144,850	14,891	9.73
December	148,912	995,796	6.69	130,900	13,237	9.81
Total	1,407,279	10,191,150	7.242	2,296,380	240,149	9.562

Construction of Wood-Stave Pipe

By R. Manly Orr

When engineers in the eastern and central parts of the country hear "wood pipe" mentioned, they invariably think of a bored log or some such crude contrivance of a temporary or emergency nature. Lately, however, the high price of steel following the war, has increased the demand for wooden pipe and it is now used in many sections. Undoubtedly few engineers are aware that a wooden pipe line 13 ft. 6 in. in diameter and approximately 1½ miles long is now in operation at the Ontario Hydro-Electric power plant at Niagara Falls.

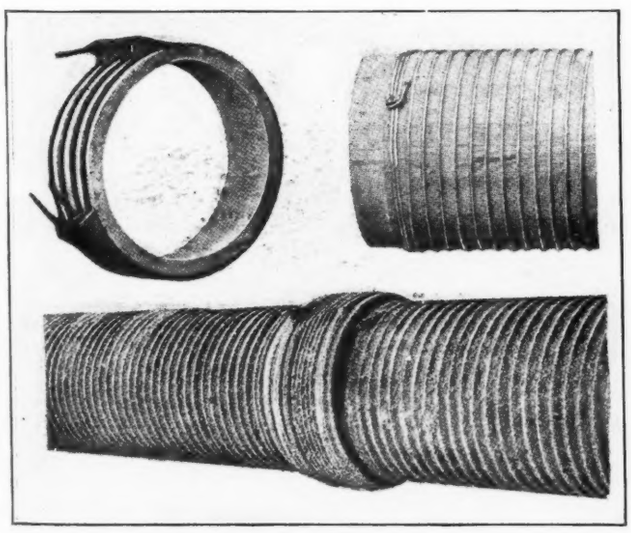


FIG. 1—CONSTRUCTION OF WOOD-STAVE PIPE UP TO 24-IN. DIAMETER

Next to the principal advantage of low cost is the adaptability for transportation, curve building and varying pressures.

Fig. 1 shows the method of construction for all sizes up to 24 in. in diameter, while Fig. 2 shows the method of construction for all sizes above 24 in. and up to 15 ft. diameter and larger.

In constructing the pipe shown in Fig. 1 the staves, which are tongued and grooved, are "chucked" in a machine similar to a lathe, which wraps on, under great tension, the galvanized steel wire of such gage and with such spacing as meets the need of the pressure to be carried. If the pipe runs up and down hills, closer spacing will be used for the valleys and wider for the elevations. The pipe lengths are driven together into a coupling, as shown in Fig. 1, by a battering ram swung over the ditch or pipe line, the blow being struck on a specially made and banded plug which is inserted in the end of each pipe length while being driven onto the line.

FIG. 2—CONTINUOUS STAVE CONSTRUCTION USED FOR LARGER SIZES

In the construction of the larger sizes, as shown in Fig. 2, the staves are not tongued and grooved, but are shipped to the job in the knockdown condition, where round steel bands threaded and fastened by malleable lugs take the place of the banding wire as used on the smaller sizes. The bands are spaced according to the head or pressure to be carried.

In this type of construction there are no individual pipe-lengths, the entire line being one continuous pipe with the joints between stave ends staggered all over the line, different lengths of staves being used. The joints between the stave ends are made by galvanized iron tongues which are about ¼ in. thick by 2 in. wide and about ½ in. longer than the stave is wide. The stave ends are slotted about 1 in. deep across their ends in a circumferential direction, and when the ends are driven together, one half of the width of the tongue is forced into the slot in each stave. Then the tongue, being ½ in. long, leaves ¼ in. tongue protruding at each end of the joint to bed into the sides of the adjoining staves when the bands are tightened up.

Ease of transportation is one of the great advantages of continuous-stave pipe, because large flumes and penstocks running to 15 ft. in diameter and over can be transported even up a mountainside or down into a

canyon, where only a man can climb, carrying one stave or a half band on his back. They can also be shipped conveniently.

Adaptability to curve building is another important advantage. All pipe is manufactured to lie straight and can be built to any reasonable curve on the job. Fig. 3 gives an idea of the flexibility of this type of construction.

As a curve is approached, the bands are put on slack, and with a sling thrown around the free end of the pipe

FIG. 3—ILLUSTRATES FLEXIBILITY OF CONTINUOUS STAVE CONSTRUCTION

it is pulled either up or down, or to either side as required, by a chainblock or other means. During this pulling process the joints at the stave ends on the outside of the curve will pull apart, and as the pull is being made the outside staves are kept driven back with a sledge and driving bar so that they never pull away from the steel tongues. When the curve is fully pulled and the end joints are all tightly driven up, then the bands are tightened and the curve will remain when the sling is taken off. This makes it possible to order pipe of a given size and length without regard to the nature of the pipe bed. for it can be laid around curves or up and down hills without either fitting or alteration.

Iron elbows are used at sharp angle bends. In wire-wound sizes the tenoned end of the pipe can tightly grip an iron nipple by virtue of its adjustable bands.

The manufacture of wood pipe is by compulsion restricted to the Pacific Coast. The Douglas Fir of British Columbia, Washington and Oregon, and the Redwood of California are practically the only timbers that will make wood pipe staves up to 35 ft. in length without knots or cross-grain.

These trees grow straight trunks with the first limb about 50 ft. above the ground, and that is the reason that practically every city of the Pacific Coast from San Francisco to Vancouver has one or more wood-pipe manufacturing industries, and their products are now being extensively used along the Atlantic seacoast and the eastern part of the country.

There are continuous wood-stave pipe lines built as early as 1890 that are still in service and lines as large as 36 in. in diameter, carrying over 200 lb. pressure per square inch.

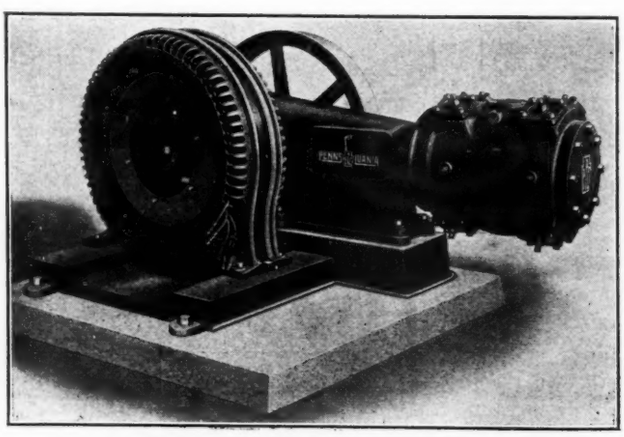
Small Air Compressors Directly Driven by Synchronous Motors

A widely used method of driving large-sized duplex air compressors is by a synchronous motor mounted directly on the compressor's crankshaft, between the two frames, instead of the belt pulley. The many advantages of direct drive with a medium- or slow-speed synchronous motor over the high-speed motor with a belt connection to the compressor, has made the former method looked upon as a standard. The Pennsylvania Pump & Compressor Co., Easton, Pa., has adapted small slow-speed synchronous motors to its air compressors of the straight-line type, mounting the motor's rotor directly on the shaft instead of the usual belt wheel.

The figure shows a standard air compressor with a cylinder of 10-in. diameter and 9-in. stroke, having a piston displacement of 240 cu.ft. of free air per minute. It is driven by a 40-hp. synchronous motor running at a speed of 300 r.p.m. and mounted directly on one end of the shaft in place of the belt wheel.

The standard practice of this company is to taper the ends of the crankshaft, reaming the hole in the belt wheel and flywheel on a taper, the wheels being drawn on by a washer and bolt in the end of the shaft. This construction, which is followed out in the mounting of the rotor of the motors, greatly facilitates the attaching of the motor, as it is not necessary to send either the shaft or the rotor to the shop to be mounted, the job being easily done when the outfit is assembled in position.

One of the objections to the use of synchronous motors has been the need of experienced attendants to start them and throw them on the line at the proper time. With the special control boards furnished with these motors, this is taken care of automatically by push-button control. When the operator wishes to start, he simply pushes the button, and the motor is started up as an induction motor. As soon as it reaches the



AIR COMPRESSOR DIRECTLY CONNECTED TO 40-HP. 300 R.P.M. SYNCHRONOUS MOTOR

proper speed, the synchronous element is automatically cut in without any attention from the operator. On account of this feature of the control it is possible to operate these direct-connected units with automatic pressure start-and-stop control. These units are built in capacities of from 150 to 600 cu.ft. of free air per minute and are driven by motors ranging in size from 20 to 100 horsepower.

Chimney Foundations

By W. WALLACE CHRISTIE*

THE pressure or load borne by the soil is that due to the dead weight of the chimney and the pressure-increment from the wind blowing against it. Foundations for guyed steel chimneys support the dead weight of the chimney only, the pressure from the wind being balanced or supported by the guy wires. Foundations for self-supporting steel chimneys, as well as brick chimneys, receive the full effect of the wind pressure in addition to dead weight.

The supporting capacity or power of the soil increases as its depth beneath the surface. It will take care of the wind-pressure load automatically. The slope of the sides of the frustum of a cone composing the foundation should make an angle of 60 deg. with the horizontal unless reinforcement is used, in which case it may be made less. According to Hotop the proper condition or balance is realized when the depth of the foundation is one-eighth of the height of the chimney, and its base breadth is about one-eighth of the height of the chimney and its foundation.

For chimneys of large diameters the depth of foundation and its width or breadth should be given special consideration. When these conditions are fulfilled, we find that the gaping or widening of the brick joints is almost entirely avoided, as the maximum pressure on the earth is not more than 35 $\frac{55}{100}$ lb. per sq.in., which is a safe value for sand and gravel. For loam or soft clay the same will apply if we are careful to have the gravity center line of dead load and wind pressure come within the middle third of the foundation baseplate; otherwise this baseplate may crack, the ground underneath soften and move out of place, and the chimney go out of plumb.

THE supporting power of soils increases with the depth; they act somewhat like a fluid. The proportioning of chimney foundations is described for various conditions, both favorable and otherwise. Foundations of chimneys should be built in the form of a frustum of a cone resting on a bottom slab so designed that the safe unit pressure on the earth or ground is not exceeded.

Non-Reinforced Footings Should Not Have Less Than Sixty-Degrees Angle to Base

The writer finds from the records of tests of cement concrete cubes, that their corners and sides break down or slough off, leaving the angle with the horizontal somewhat less than 60 deg. This also bears out the opinion of G. Lang; therefore when designing footings or foundations of concrete with no metal reinforcement, we find no advantage in having the angle of the bounding sides of the foundation to the base less than 60 deg.

Should the center of gravity or zero pressure in quadrangular chimneys waver but little from the center point, we avoid the cracking of the baseplate referred to and may also save some expense by cutting off the corners, making the baseplate octagonal in plan.

Red-brick or radial-brick chimneys require this baseplate to be built of broken stone or concrete well rammed into a homogeneous mass, having a thickness $T = 1.64 + 0.01H$. T and H represent the thickness of base and chimney height in feet. The concrete mixture is to be proportioned, $C:L:S:B = 1:0:4:7$ to $1:1:4:7$, according as it is desired to be watertight, where L is the lime mortar, B stone, C cement and S sand.

There are some exceptions to the foregoing rule, as follows:

1. When the foundation rests on the solid rock, then its height and width can be reduced.

2. When the earth at given depth has less supporting power, as previously given, it can then be solidified by ramming dry gravel into it. If the earth is very wet wooden piles are to be driven, having their tops cut off twelve inches below water mark, laying over them a heavy mass of Portland cement concrete reinforced with steel bars.

3. When ground water stands high, the foundation plate should go down as little as possible; the bounding planes of the foundation can then make a less angle than 60 deg. with the horizontal and be strongly reinforced without.

4. When adjacent property or buildings interfere with the plan of the base, enlarge the same in all directions possible, reinforcing the baseplate with old steel rails, heavy steel angles or I-beams.

Practically all soils[1] possess elastic properties, the amount depending on the character and quantity of the cementing material giving it the cohesion, as well as the water content. If unequal loads per unit of area are placed on such soil, unequal settlements will take place. The soil, however, will recover on the removal of the loads unless the latter are great enough to overcome its elastic properties, by breaking down its cohesion.

Surrounding Pressure at Greater Depth Increases Soil-Supporting Power

Such action is most apparent at some depth beneath the surface as the displacement is retarded by the restraining action of the surrounding soil. This unequal settlement, though slight, may be sufficient with certain soils and structures to cause trouble.

As evidence of such action the rebound, or rising [of piles forced into the soil by direct pressure] after releasing the jacks, may be mentioned. The action is also apparent on releasing jacks and wedges when cribwork is used in temporarily supporting heavy loads, as in the underpinning of buildings, etc.

The increase in the supporting power of soils as the depth becomes greater is due to pressure on all sides, making, as it were, an envelope preventing the movement of the soil.

A. E. H. Love[2] says the surface of discontinuity between displacements from and to the central axis is also a cone, the angle of divergence of which for an isotropic

*Consulting Engineer, Ridgewood, N. J.

[1] Proceedings A.S.C.E., Vol. 46, p. 900.
[2] Trans. A.S.C.E., Vol. 85, p. 1573.

solid is roughly 68 deg.; that is, the sides of the triangle make an angle of about 32 deg. with the vertical. (The author thinks 22 deg. is correct.)

Tests[6] to demonstrate the law of frictional "upbuild" due to slight resistance of envelopes, gave in part the results shown in the table.

TESTS INDICATING FRICTIONAL "UP-BUILD" OF SOILS

	Total Load, Lb.	Supported on	Lb. per Sq.Ft.
Mailing tube 3½ in. diam. x 6 in. high shellacked on inside. Hoop tension effect adds to supporting power	4,520	gravel fill	67,666
Cyl. 4 in. diam. x 14 in. high paper*	860	gravel fill	9,847
Cyl. 4 in. diam. x 14 in. high tracing cloth*	620	Ottawa sand	7,100
Cyl. 4 in. diam. x 14 in. high tracing cloth*	940	gravel fill	10,763
Cyl. 4 in. dia. x 14 in. high tracing cloth shellacked	740	gravel fill	8,473

* No Compressive Strength.

Foundation Dimensions for Self-Supporting Steel and Concrete Chimneys

The first Brooklyn Bridge piers are safely founded on sand because there are no rifts in the surrounding medium. This may explain why some buildings collapse when the earth or surrounding media of the foundations are disturbed.

The author's formula[4] for self-supporting steel-chimney foundations is $D = \frac{h^2 d}{26{,}000} + 10$ where D is diameter in feet of the baseplate of the foundation, h = height of chimney in feet, d = diameter of chimney in feet. This may be increased somewhat if found necessary, because of soft or wet earth or loose sand.

For concrete chimneys an octagonal baseplate can be used, and in order that there shall be no tension in the soil, this formula[5] applies: $D \times W = 0.045\ d\ h^2$, where W = weight of entire chimney in tons. This baseplate is to be reinforced with steel bars.

Careful calculations should be made of the areas of baseplates and load carried by the earth under them, to see if the safe figures previously mentioned have not been exceeded.

The Friction Heater

The inventive mind has been a wonderful boon to the human race, and it cannot be denied that many inventions of great importance have originated with men whose knowledge of fundamental principles was not of the best. At the same time the combination of inventive ability and ignorance of well-established natural laws is the seed from which springs a never-failing crop of freaks.

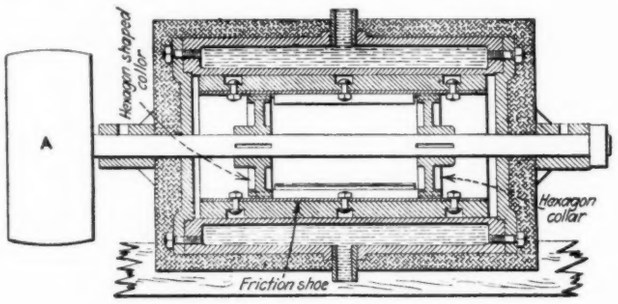
A recent invention in this field is the "friction heater," one form of which is shown in the accompanying diagram, based on the patent drawings. Operation is as follows: The pulley *A*, rotated from some outside source of power, turns a spider, on the outside of which are several wooden blocks, each of which is pivoted along one edge. Centrifugal force throws the blocks outward, so that they press on the inner surface of the water-jacketed metal cylinder with a force depending on the speed of rotation.

The resulting friction heats the water, which is used (as hot water or steam) in "heating systems, in which smokestacks and boilers, with connecting mechanism, may be entirely eliminated." This is bad news for the manufacturers of heating boilers!

[3]Trans. A.S.C.E., Vol. 46, p. 934.
[4]"Chimney Design and Theory," by W. W. C., p. 57.
[5]Engineering News-Record, Vol. 87, p. 512, article by W. W. C.

The following quotations from the prospectus of the Friction Heater give some surprising scientific information in regard to this invention:

This invention is a device for extracting latent heat from the molecules of the metal and for utilizing said heat as a means of superheating air, vapor, gas and liquids, and for the further purpose of providing a superheating union for the raising of temperature of liquids, gas and other vapors, when expansion facilitates the pressure of flow for transmission or for immediate use. Principles involved, rolling, revolving or sliding friction.



CROSS-SECTION OF FRICTION HEATER

In presenting a new process for utilizing electric energy, or other power, as a method of exciting the latent heat lying dormant in metal, we take pleasure in giving out to the public an explanation as to how we utilize such forces of power and produce and generate steam by friction, generally speaking, with practically no wear or tear, avoiding the usual brake load as recognized.

When the motor power is turned on it revolves the shafting and wooden core at a given speed. The revolution of the core heats the cushion of air inside the cylinder, which in turn excites the molecules of the metal, thus throwing off the latent heat, before lying dormant in the metal, thereby heating the water and producing steam. It is not contrary to science. It is simply the ABC of science properly applied, which, up to the present time, scientists have never given the world.

This explanation may well be described as a "knock-out" and leaves little more to be said. Speaking seriously, no one can deny that this apparatus would produce heat from power, or that most of the power delivered by the driving motor would appear as heat in the circulating water of the apparatus. Certainly a house could be heated in this fashion, but with electricity at 6 cents per kilowatt-hour, the yearly bill would probably exceed $2,000. In those very rare instances where it is possible to sell hydro-electric power at a fraction of a cent per kilowatt-hour, thus bringing electric house heating within the range of economic possibility, electrical energy can be turned into heat by the use of resistance elements without the complicated paraphernalia of motor and friction heaters, which is simply a highly roundabout method of accoplishing the same purpose.

While poking fun at some of the absurd notions of the inventor it must be admitted in all fairness that there are several conceivable uses of a "friction heater." For example, a railway caboose might be heated in this fashion, if those in charge were willing to add appreciably to the coal consumption of the locomotive.

A Correction

The illustration of the Foerst Oil Burner appearing in *Power*, Aug. 21, covered the external-atomizing conical flame burner and not the Foerst inside-atomizing burner discussed in the text.

Recent Developments in Flue-Gas Analysis

By E. H. LOCKWOOD
Assistant Professor of Mechanical Engineering, Yale University

THE excellence of combustion can be estimated most conveniently by an analysis of the gases of combustion, or the flue gases. It is known by theory that each fuel requires for complete combustion a proportionate weight of air. It is not enough, however, to supply fuel and air in theoretic proportions, since in all solid fuels a considerable excess of air is required to insure complete combustion. Flue-gas analysis is of great value to the engineer, as it furnishes him with direct evidence as to the completeness of combustion and the amount of air used.

Analysis of the flue gases can be made by anyone after a little practice, with the aid of the familiar Orsat apparatus. It will be unnecessary to describe the apparatus here, but a brief reference may be made to its method of use.

The gas is drawn into the apparatus by the water-displacement method, actuated by a leveling flask in the hands of the operator. The sample is first drawn into a chamber with a scale etched in the glass, where its volume is read. The sample is then passed in succession into three absorption bulbs, where the constituents of the gas are absorbed, being returned each time to the measuring chamber to note the amount of absorption. After determining the three components by absorption, the sum is subtracted from 100 and the remainder is called nitrogen. The analysis is then reported on the percentage basis as follows:

Carbon dioxide (CO_2)	.....
Oxygen (O_2)	.....
Carbon monoxide (CO)	.....
Nitrogen (N_2)	.....
Sum	100.0

The gaseous components will vary according to the amount of air supplied with the fuel, but the nitrogen item will always be a large part of the total, say over three-fourths.

After the analysis has been made, it remains to interpret the results. The CO item gives direct information as the completeness of combustion: If the CO is zero, or quite small, combustion is about complete. Having obtained information as to the quality of combustion, we need to know how much excess air was required to obtain it.

Flue-Gas Computations Reduced to Simple Formulas Based on Gas Analysis

Recent developments have simplified the computation of air supply from the flue-gas analysis figures. The process has been reduced to an algebraic formula where the values are merely substituted and worked out, without the use of atomic weight or other constants.

The theoretic air supply will be computed first, as it forms the basis with which the actual air supply is compared. It might be assumed that reference to the fuel would be necessary to compute the weight of air for its complete combustion, but such is not the case. The theoretic air supply can be found from the flue-gas analysis by means of formula (1):

$$\textit{Theoretic air per pound of combustible} = \frac{18.3N_2 + 34.8CO - 69.6O_2}{0.525N_2 + 5CO + 4CO_2 - 2O_2} \quad (1)$$

In using the formula, the numerical values of CO_2, O_2, CO and N_2 are substituted as given by the flue-gas analysis. It is worthy of mention that formula (1) is theoretically correct for all fuels, solid, liquid or gaseous, with the exception of one kind of gaseous fuel to be mentioned later.

Having computed the theoretic air supply from the gas analysis, it will be in order next to compute the air actually used by the same fuel. This can be done by means of formula (2), which resembles (1), and like it applies to all fuels with the single exception noted.

$$\textit{Air used per pound of combustible} = \frac{18.3\,N_2}{0.525N_2 + 5CO + 4CO_2 - 2O_2} \quad (2)$$

Formulas (1) and (2) give complete information as to the air supply for the combustion in question.

Two examples will be given of the application of the foregoing formulas, for a solid and for a liquid fuel.

Computing Percentage of Excess Air

Example 1: Flue-gas analysis from semi-bituminous coal under a power boiler. $CO_2 = 11.8$, $O_2 = 7.7$, $CO = 0.2$, $N_2 = 80.3$

Theoretical air per pound combustible, by (1)	12.7
Actual air per pound combustible, by (2)	19.4
Excess air used, per cent	54

This test shows that CO was present in small quantities in the flue gas, even with a large excess of air.

Example 2: Flue-gas analysis from a gasoline engine (average value given in Judge's "Automobile and Aircraft Engines," page 20) $CO_2 = 12.5$, $O_2 = 0.2$, $CO = 2.6$, N_2 (by difference) $= 84.7$.

Theoretical air per pound of combustible by (1)	15.2
Actual air per pound of combustible by (2)	14.5
Deficiency of air used, per cent	4.6

In this case the mixture was slightly over-rich, as less than the theoretic air supply was used.

Another development of importance is a method of proving whether the gas analysis itself is correct. The Orsat apparatus permits of considerable accuracy, yet unsuspected errors may arise from sources such as partially exhausted chemicals, accidental leakage past stop cocks, mistakes in reading the percentage scale, etc.

The simplest check on the gas analysis is to compare the theoretic air weight computed from formula (1) with that calculated from the fuel analysis. For this comparison it is usually accurate enough to take the analysis from handbooks for the fuel in question. If the air weight computed by the two methods agrees substantially, the flue-gas analysis may be assumed correct.

Otherwise the Orsat may be suspected of error and the analysis repeated.

In order to carry out this method, it is convenient to have at hand a table of values of the theoretic air required by different kinds of fuel. Such values are given in Table I. Column 1 gives the name of the fuel. Column 2 gives the percentage of volatile matter for classification of the fuel. Column 3 gives the theoretic air requirement computed from the ultimate analysis, based on one pound of combustible.

TABLE I—THEORETICAL AIR REQUIRED FOR PERFECT COMBUSTION

Fuel	Volatile Matter, Per Cent	Theoretic Air per Lb. of Combustible
Pure carbon	0	11.6
Gas coke	2.5	11.82
Anthracite coal	6.2	12.22
Semi-bituminous coal	21.0	12.65
Bituminous (Pittsburgh)	37.0	12.85
Gasoline C_6H_{14}	..	15.21

Referring now to the two examples mentioned in this paper, the check for correctness may be made as follows: For the semi-bituminous coal, formula (1) gives a theoretic air weight of 12.7 lb. as compared with 12.65 lb. from the table for the same kind of fuel. For gasoline, formula (1) gives a theoretic air weight of 15.2 lb. as compared with 15.21 from the table. Therefore, it may be assumed that the gas analysis in both cases was substantially correct.

Formula for Checking Orsat Analysis

The correctness of the Orsat analysis may be proved by a second method which, while no simpler than the first, has some interesting features. By equating the two expressions for theoretic air, one from the gas analysis and one from the fuel analysis, there results a definite relation between the quantities CO_2, O_2, and CO for each fuel. In other words, the gas analysis components, CO_2, O_2 and CO, are not independent, but are bound together by an algebraic relation to which each analysis must conform. This relation takes the form given in equation (3), where m, n and k are constants depending on the analysis of the fuel.

Orsat-analysis Check Formula,

$$CO_2 + mO_2 + nCO = k \qquad (3)$$

TABLE II—CONSTANTS FOR ORSAT-ANALYSIS CHECK FORMULA

Fuel	m	n	k
Pure carbon	1.00	0.60	20.9
Gas coke	0.98	0.614	20.35
Anthracite coal	0.95	0.63	19.52
Semi-bituminous coal	0.91	0.645	18.7
Bituminous coal	0.88	0.652	18.4
Gasoline	0.70	0.71	14.5

If the Orsat analysis is correct, equation (3) should prove when the values of CO_2, O_2 and CO are inserted in it. Referring again to the examples in this paper, for semi-bituminous coal, $m = 0.91$ and $n = 0.645$ and the first member of formula becomes 18.94 while the second member is 18.7. This agreement is not perfect, but does not indicate sensible error in the gas analysis.

For the second analysis (gasoline) $m = 0.70$ and $n = 0.71$, so the first member of the check formula becomes 14.48 while the second is 14.5. This method, like the first, proves the correctness of the flue-gas analysis as given in the example.

It is sometimes assumed that the sum of $CO_2 + O_2 + CO$ for different analyses is constant. Formula (3) shows that this is approximately true for coal, where the CO item is either zero or very small. However, the modified sum as given in formula (3) is constant for all fuels.

In addition to the foregoing formulas for actual and theoretic air, several others have been derived to extend the information that may be obtained from the flue-gas analysis. These formulas[1] are appended for the benefit of engineers who may have occasion to make a detailed study of some combustion problem.

Dry gas per pound of combustible =

$$\frac{22CO_2 + 16O_2 + 14(N_2 + CO)}{0.525N_2 + 5CO + 4CO_2 - 2O_2} \qquad (4)$$

Percentage of excess air =

$$\left[\frac{69.6O_2 - 34.8CO}{18.3N_2 + 34.8CO - 69.6O_2}\right] \times 100 \qquad (5)$$

Water vapor per pound of combustible =

$$\frac{4.77N_2 - 9CO - 18(CO_2 + O_2)}{0.525N_2 + 5CO + 4CO_2 - 2O_2} \qquad (6)$$

Percentage of carbon in combustible =

$$\left[\frac{6(CO_2 + CO)}{0.525N_2 + 5CO + 4CO_2 - 2O_2}\right] \times 100 \qquad (7)$$

Percentage of hydrogen in combustible =

$$\left[\frac{0.525N_2 - CO - 2(CO_2 + O_2)}{0.525N_2 + 5CO + 4CO_2 - 2O_2}\right] \times 100 \qquad (8)$$

Ratio of carbon to hydrogen in combustible =

$$\frac{6(CO_2 + CO)}{0.525N_2 - CO - 2(CO_2 + O_2)} \qquad (9)$$

These formulas, as well as formulas (1) and (2), apply to any solid, liquid or gaseous fuel in which the amounts of nitrogen and sulphur are negligible, so they apply with reasonable accuracy to all commercial fuels except producer gas and blast-furnace gas. It is further assumed that there is no free hydrogen or other combustible except CO in the flue gas. Wherever "hydrogen" occurs in the formulas, it refers to the free hydrogen, the part that requires air for its combustion.

To sum up, the formulas here given make possible a wide variety of accurate combustion computations without knowledge of the composition of the fuel. If, in addition, account is taken of the general nature of the fuel, it is possible to check the consistency of the gas analysis on which the other computations are based.

More thorough methods of cleaning condenser tubes, which are employed when the unit can be taken out of service for a sufficiently long period, are the wire-brush method, the tube-boring machine and the sandblast. In the wire-brush method a stiff round wire brush is pushed or pulled by means of a long rod through each individual tube. A good job is done by this method with little damage to the metal of the tubes. Where hard scale is encountered, tube-boring machines are sometimes used, but the cleaning is particularly slow and the wear and tear on the tubes is a factor. The use of the sandblast is probably the most satisfactory and expeditious way of removing the deposit. About a quart of clean, sharp sand that has been dried should be used to a tube. One operator can clean about 100 tubes an hour. The heat transmission after thoroughly sandblasting the tubes is usually as good as, and sometimes better than, when the unit was originally installed. If care is taken, there will be little cutting of the tube metal.

[1] The derivation of all these formulas may be found in the March issue of the Journal of the Society of Automotive Engineers.

EDITORIALS

F. R. LOW, EDITOR

Analyzing Coal With an Orsat!

CAN coal be analyzed with an Orsat apparatus? Strictly speaking, it cannot. It does, however, appear to be possible from an analysis of the flue gas alone to make a large number of combustion computations for which it was formerly considered necessary to have the ultimate analysis of the coal. This ultimate analysis, which can easily be invented for a textbook to suit any problems being worked out, is in practice a matter involving much expense and trouble. The engineer confronted with a practical problem in combustion is exceptionally fortunate if he has at his command an ultimate analysis of the fuel used.

The Orsat apparatus, unlike that required for ultimate analysis of coal, is not beyond the reach of the average well-equipped plant. The apparatus can be purchased for a moderate price, and the engineer needs only a little practice to make accurate determinations of CO_2, O_2 and CO. Having completed the analysis, he can, by means of the formulas given in the article on page 461, work out practically any desired combustion problem. Moreover, he can even get a check on the accuracy of the anaylsis itself. It is believed that these formulas have a broad field of practical application.

Production Versus Distribution Costs

IN MOST lines of industries at the present time there is a tendency toward the combination of small concerns into one large company. In manufacturing of products of general use this drift is pronounced; the basis for the action being, so it is stated, the economies possible through mass production. In power generation the process has been developed to such an extent that some predict the ultimate construction of a few superpower stations to supersede the hundreds of small plants.

In the refrigerating industry the trend is in a contrary direction. In place of a single large ice plant supplying a city, at the present time engineers believe that a number of small plants located in the several centers of demand will show lower total costs per ton of ice delivered than is possible in a single central plant. Of course in former times it was almost impossible to locate a steam-driven ice plant in a residential district and the large plant placed along the railroad or river bank was necessary. With the advent of cheap electric power rates and of the highly efficient oil engine, the small plant is made possible.

As with all manufacturing, the actual production cost is but one item in the long list of expenses. Quite frequently the cost of distribution equals or exceeds the purely production costs; this is specially true in ice manufacture. The substitution of many centrally located small plants for a large factory, while it may increase the production costs by ten per cent, will, at least in the case of ice, reduce the distribution expense by from twenty to seventy per cent. The advantage is obvious.

Probably the most important manufacturer to turn the public's attention to this comparison of production and distribution costs is the Ford Motor Company. This company now makes use of the plan of sub-factory assembly and distribution in preference to the centering of all activities at the main factory. It is still an open question as to the economy of centralized manufacturing in any line, especially those where distribution—haulage, freight rates, transmission losses or whatever form it takes—is a considerable part of the total selling price.

Primary and Secondary Causes of Vibration in Steam Turbines

WHILE a steam engine would tend to knock or weave as a result of misadjustment or other abnormal conditions, a steam turbine ordinarily indicates such undesirable circumstances by vibration or noise.

In classifying vibration the terms primary and secondary may possibly be employed, representing relative importance, and a group of possible causes assigned as producing primary or secondary vibration. A sprung spindle may be spoken of as a cause of primary vibration inasmuch as it could alone produce serious vibration. Secondary vibration may be assigned to minor causes such as rubbing of packing or sealing rings.

There is, however, an evident fallacy in defining causes with regard to the importance of vibration produced. Any single cause may produce vibration of major or minor importance. A sprung spindle, when sufficiently bad, may cause serious trouble. If present to a less extent, the vibration may be so slight as to be noticeable with difficulty and not worth correction, and therefore minor in character. On the other hand, some types of impulse turbines which exhibit practically perfect operation, may have a noticeable untrueness in the shaft at low speed or normal speed. Attempts to balance with the purpose of causing the shaft to run true at normal speed would in some cases be decidedly unsuccessful as applied to the turbine in the plant. Any single cause may be serious or negligible in extent and in effect, representing either a primary or secondary group in such a classification.

In classifying abnormal conditions of this character, it seems reasonable to disregard whether the effect is serious or negligible and define the cause as primary or secondary with regard to its relative importance. The former group applies when a single cause is directly responsible, and the latter group when it is a contributing factor and not alone responsible. Essential causes and contributing causes as definitions, would cover the situation to better advantage. The latter group could be subdivided into major, minor or equally contributing factors.

A machine in bad balance would ordinarily be well

corrected before leaving the factory and thus the essential cause removed. The degree of smoothness in operation attained may be regarded as perfect when installed on a foundation of the usual type. If such a set were placed on an exceptionally flexible steel platform, where a tendency to sympathetic vibration was sufficient, roughness might result with unbalance as a contributing cause, either major or minor. Usually, such a condition would be dealt with by stiffening the steel support so as to reduce its sympathetic quality sufficiently. Rebalancing to a greater degree of fineness may solve the trouble, but the strong tendency to sympathetic vibration would then remain as an undesirable menace to any slight misadjustment or abnormal condition of either a reciprocating engine or turbine.

Any condition, such as unbalance, misalignment, or insufficient lubrication, may therefore belong to either classification, depending on its relative importance in producing vibration.

Are Worn Elevator Cables Condemned Too Soon?

WHEN should worn elevator cables be condemned? This is a question that is still an open one in the minds of engineers. There are certain arbitrary rules that may be applied, but just why these should be used is based more on conjecture than on definite information. If some means were available for determining the reserve strength of worn cables and it was known what the minimum safety factor should be, then the time to remove a cable could be ascertained. The article in this issue on the "Strength of Worn Elevator Cables," is of particular interest, as it gives the results of over one hundred and fifty tests on condemned cables and forty-three tests on wires taken from these cables.

In applying the results of these tests, one must do so with discretion, since a variation in the conditions from those under which the cables used in the tests, operated may give entirely different results. The specimens in these tests were taken from cables used on one-to-one traction elevator machines that had been under the care of an engineer who had made a very careful study of the factors that influence the life of elevator cables. Specimens taken from cables used on a similar machine but operating under different conditions may show dissimilar results; for example, where the cables are not properly socketed or kept lubricated or where the grooves in the sheaves have become worn to different diameters. The effects on the reserve strength of cables of a V-grooved sheave used in a single-wrap machine may be different from that of the semicircular grooving of a double-wrap machine. Then again, on a two-to-one traction or a drum-type machine where reverse bends are made in the cables, the reserve strength for a certain visible condition may be materially different from that for cables that have not operated with reverse bends. Therefore, even though these tests represent one of the most valuable contributions to the information on elevator cables, care must be used in applying the results.

Tests made on new cables have shown that when the broken wires are equally distributed in the different strands, the cable will have a higher percentage of its original strength than it has percentage of the original cross-section of metal. Where the broken wires are in one or two strands, the percentage of reserve strength is less than the remaining percentage of cross-section of metal. Therefore the distribution of the broken wire is also a factor in the reserve strength of the cables.

The complications entering into the problem make it apparent that it will be difficult to formulate a general method of closely determining the reserve strength of cables. However, this is not so important as information on which to base some practical rules that can be easily applied in a way that will insure that the cables will not be removed before a large percentage of their safe useful life has been obtained and also to indicate when they have reached the danger point. Where elevators are given proper attention failures of cables are practically unknown in normal operation. This would indicate that these cables are renewed before they become dangerous, but how long before is not known. Some of the best authorities believe that in many cases cables are removed too soon. Before a general decision can be made, more information will have to be available for cables operating under a wider variation of conditions than at present.

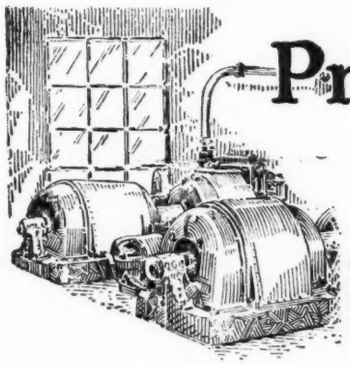
A Fair Basis for Comparing Fuels

IT HAS long been recognized that the price of a fuel at the mine, or even the delivered price, means little considered apart from quality. The quality of a fuel may be stated in various ways, but the calorific value as determined by the bomb calorimeter or from analysis has become the general standard, so that coals and other fuels are often compared on the basis of cost per thousand B.t.u. or the B.t.u. obtainable for one cent.

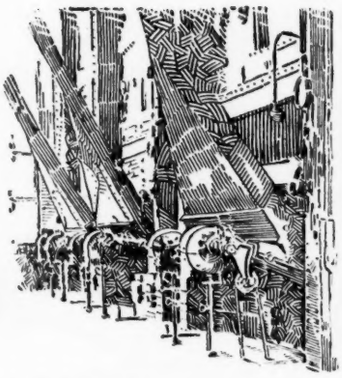
In comparing fuels in this way, practical engineers have not entirely overlooked the fact that the calorific value does not tell the whole story. The calorific value shows the amount of heat evolved under the practically perfect conditions of the bomb calorimeter. In the last analysis the engineer is interested in the amount of heat he can get into the steam, hence he is necessarily concerned with any facts about the fuel that affect the efficiency with which the calorific value can be turned into useful heat in the boiler. It is well known that high ash content tends to increase the total loss of combustible in the ashpit refuse and that it also decreases the efficiency of the furnace by making the maintenance of a uniform fire, free from holes, more difficult. Again, the moisture in coal must, at least in all present-day commercial boilers, be heated up, evaporated and then thrown away in a superheated condition. This involves a loss of available heat.

The article on page 448 shows one way in which the disadvantage due to high ash and moisture may be evaluated in dollars and cents, making possible a comparison of coals on the basis of cost of heat actually available in practical installations. The method shown seems to have real possibilities, but could probably be improved by certain additions. It would seem, for example, that some rough allowance should be made for the probable effect of the nature of the fuel on furnace life and repairs and also for the effect of ash percentage on total ash-handling costs.

Another element of considerable importance is the moisture produced by the hydrogen in the coal. This "manufactured" moisture is usually far greater than that originally present as such in the coal and produces a correspondingly greater loss on being thrown to waste as a superheated steam. To be consistent the comparison should include this item.



Practical Ideas *from* Practical Men



Does a Partly Closed Feed Valve Increase the Duty on the Feed Pump?

I would like to have the opinion of other engineers as to the difference in the duty on a feed pump when pumping water to the boiler with the feed valves partly opened, say a turn and a half or two turns, and with the feed valves wide open.

Does the velocity of the water through the partly opened valve cause more strain on the pipe line? Would it cause vibration to be set up in the feed line?

My contention is that a pump working against 150-lb. pressure with the feed valves wide open and regulated at a speed just sufficient to feed the boilers, will work quieter and with less strain on the feed line. I would appreciate the advice of *Power* readers whom I feel will be interested in this subject.

The difference in the working of the pump under these two conditions may not be noticed in an up-to-date plant where feed lines are properly installed with long-radius bends, gate valves, etc., but in a small plant usually very little attention is paid to what extent the feed valves are open, or to the duty on the feed pump, as long as the boiler gets sufficient water. A. L. HARRIS.

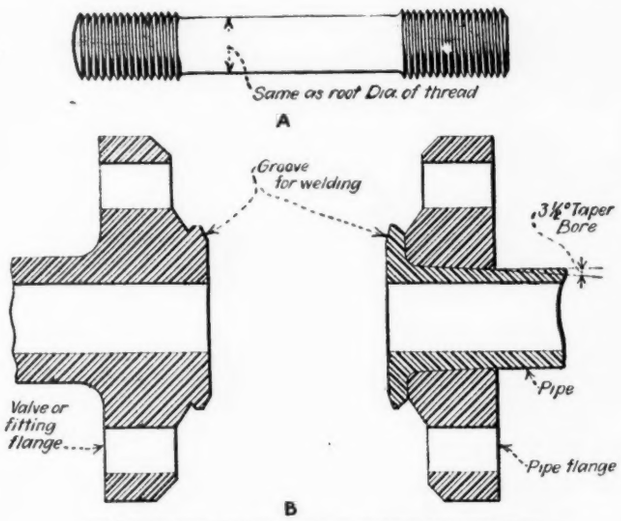
Seattle, Wash.

Standardizing High-Pressure Valves and Fittings

There are at least six different standards for high-pressure pipe joints now before the American Society of Mechanical Engineers for consideration. It is my opinion that the American Extra Heavy Standard bolt circle and number of holes is the most satisfactory templet for steam pressures up to and including 500 lb.; flange thickness and diameter of bolts should be scientifically determined to withstand the service. This bolt circle, being smaller than the 800-lb. hydraulic, tends to keep the bolts close in to the neck of the casting and to eliminate the unequal temperatures between the bolting and piping proper, thereby minimizing the unequal stress or distortion of flanges at time of heating or cooling. Furthermore, this bolt circle is satisfactory from a viewpoint of accessibility, as there is sufficient room between adjacent nuts and between the body wall and corners of nuts to allow for their removal without special wrenches. It is not necessary to remove the entire fillet either by spot or back facing in order to secure bolt clearances.

Increased body metal thickness for steam pressures above 500 lb. requires a larger bolt circle diameter than extra-heavy. The 1,200 hydraulic standard as regards bolt circle and number of bolt holes is recommended for pressures of 600 lb. and over. This bolt circle is somewhat too large for 600-lb. service, but is quite satisfactory for 800- and 1,200-lb. In order to eliminate an extra standard, it can be recommended for 600-lb. service.

Special alloy steels have been used to a considerable extent as has also forged steel. Heat-treated steels have not always been satisfactory, as continued stress at high temperatures has at times caused crystallization, and in one instance it was found necessary to replace all bolts on main steam lines in a central station because of this change in structure. Considerable trouble has been experienced by failure of bolts due to cracking of heads. To avoid such difficulties, double end studs as shown are strongly recommended. The



BOLT BODY TURNED TO ROOT DIAMETER FOR HIGH PRESSURE JOINT

body of the stud is turned to the same diameter as the root of thread. In a standard bolt such as commonly used, all expansion must occur at the root of threads which are not engaged with the nut as this is the least sectional area, whereas studs as in the figure have this elongation distributed over a considerable length. One of the largest English turbine manufacturers uses this type of bolt extensively.

Eight threads per inch for bolts 1⅛ in. and larger, is also recommended. In addition to making a stronger stud, it is much easier to make up a tight joint than with studs having a coarser pitch thread.

High steam pressure has necessitated high gasket pressure, or ratio of steam pressure to bolting pressure

per square inch of gasket surface. In order to keep bolts and flanges from becoming excessively heavy, the width of gaskets has been reduced and exceedingly narrow gaskets are now used exclusively on high-pressure work.

Tongue-and-groove and male-and-female type joints, having narrow gasket faces, are dependable, but should repairs or replacements become necessary, it is difficult to remove such a joint from a line and for this reason their application is limited. The Vanstone joint for high pressure must have considerable lap or radial bearing surface in order to hold the pipe in the flange, which means a wide gasket face, and this in turn necessitates extra flange thickness to prevent failure.

The welded Vanstone, or Sargol joint, as more correctly known, is a very satisfactory type for high pressures. The typical construction of such a joint is shown. The pipe is upset and flanged over, similar to Vanstoning, but has a specially machined face or bevel to receive the ring weld. The pipe is gripped back of the heel of the lap by a taper bore in the flange, which gives a more satisfactory joint than is obtained by having the flange loose over the pipe and all the bearing on the heel of the lap.

Four factors of safety could readily be agreed upon by manufacturers if they grouped their product according to the following operating conditions: (a) Cold-water working pressure, no shock; (b) saturated steam and low temperature gases; (c) superheated steam and all high-temperature work, such as found in the refinery industry; (d) cold-water working pressure with shock. Each of these subdivisions would carry a different safety factor; division (a) being smallest and a corresponding increase with division (d) having the largest factor.

Only such dimensions as determine interchangeability should be standardized. These would include all flange dimensions, as diameter, thickness bolt circle and drilling, face-to-face and center-to-face dimensions of fittings only. The question of metal thickness, to a large degree, is determined by the quality of mixture of steel used. Molding and foundry practice should therefore be left to the individual manufacturer, who should, however, conform to a schedule for factors of safety, as previously outlined. Face-to-face dimensions of fittings could be easily standardized, but it is scarcely possible that face-to-face of valves can be standardized. Many factors, such as type of seats, disks, bonnets and diaphragm walls in globe-valve bodies, determine the over-all dimensions. Any standard would make the internal construction of all valves nearly alike, which would discourage improvement in design and eliminate competition on a quality basis.

H. A. PEARSON, Engineer,
The Edward Valve and Manufacturing Co.
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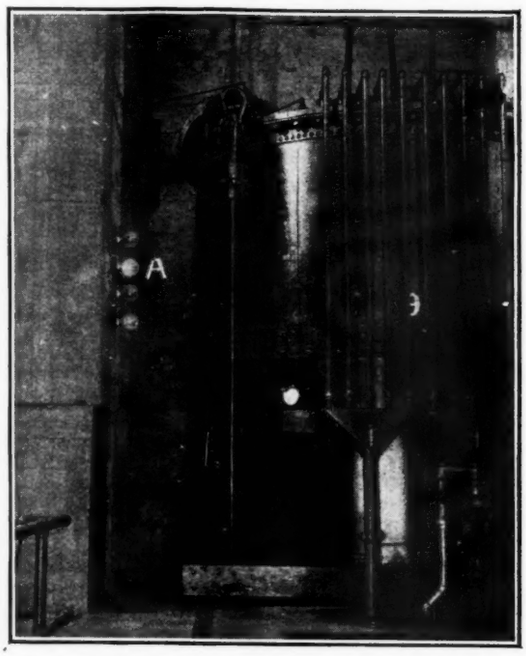
Transformer Signal Lamps To Indicate Units in Service

In order that the temperatures of the water-cooled transformers might be more easily maintained within the prescribed limits, and to indicate the transformers in operation, the signal lamps shown at *A* in the figure were installed in each of the transformer bays in a large hydro-electric station. These lamps are standard 50-watt tungsten units. Each is inclosed in a glass globe 7 in. in diameter, which is crystal roughed inside and lettered in black on the outside. Beginning at the top, the designation on the first and second globes is "H.T.O.S.," and the marking on the third and fourth globes is "L.T.O.S.," corresponding to the transformer high-tension and low-tension oil switches, respectively. The lamps in the first and third globes, counting from the top, are frosted red; being energized when the high-tension and low-tension oil switches are closed, and those in the second and fourth globes are frosted green, being energized when the transformer switches are open. These lamps are connected in parallel, through eight wires with the signal lamps mounted on the switchboard panels to indicate automatically the open and closed positions of the electrically operated oil



SIGNAL LAMPS TO SHOW POSITION OF OIL SWITCHES LOCATED AT *A*

switches. The transformer signal lamps thus indicate to attendants on the generator floor the transformers that are in operation.

Although instructions are telephoned to the governor man by the switchboard operator when the cooling water is to be turned on or off, the signal lamps serve to identify the transformer designated, thus reducing the possibility of the water being cut off of a transformer carrying load. The electrical attendant whose hourly tour of inspection includes an inspection of all station transformers, being guided by the signal lamps, regulates the supply of cooling water in accordance with their indications and according to the transformer temperature.

After the cooling water is cut off, the switchboard operator, who is notified, places a small fiber tag lettered "Water Off" at the plate representing the transformer on the switchboard. This tag is removed when the cooling water has been reported turned on. Where double bus connections employing two low-tension and two high-tension oil switches are used, a signal scheme like this described would require 8 lamps and 16 conductors, resulting in undesirable complications. By using auxiliary switches that may be mounted on the oil switches, these complications can be avoided.

C. M. KING.
Philadelphia, Pa.

Comments from Readers

Air Compressor Got Red Hot

I read with much interest in the Aug. 14 issue, Mr. Lacey's experience with the air compressor. It is not a new thing for an air compressor to get hot. I have had some thirteen years' experience with compressors and during that time I have had many peculiar experiences. In my opinion the cause of a compressor heating beyond that set up by the compression, is due to leaky discharge valves allowing the air to churn back and forth. The recompressing of the air causes the temperature to increase until the ignition temperature of the oil is reached, and the oil then burns within the compressor and causes the overheating. One method of overcoming this trouble that is often resorted to, is to feed soapy water into the air cylinders. The water coming in contact with the hot surfaces tends to cut away all of the carbonized oil that has collected on the valves and seats and keeps them in good working order. Maybe some other readers have a more practical method of doing this, if so I would like to hear from them through the columns of *Power*. J. M. FRANKLIN.

Buffalo, N. Y.

Following A. Lacey's suggestion in his comments on "Air Compressors Got Red Hot," in the Aug. 14 issue, I will give two bits of experience that may be of interest to operators.

Some time ago we had just started a 500-hp. vertical-type Diesel, which has a three-stage compressor driven by the crankshaft, when the high-pressure line carrying approximately 900 lb. pressure began smoking near the compressor. The heated area seemed to be extending toward the storage and blast bottles so that the machine was shut down as quickly as possible, and we opened the drain in the line. As the air or burning gas began escaping, the drain valve rapidly turned a bright red, and exploded before it could be closed. A new drain valve was put on, and the machine was going again in about five minutes after the shutdown. There has since that time been no further trouble with heating.

The next experience came some weeks later with another unit, equipped with a two-stage compressor. The compressor was furnishing a poor supply of air and presently the low-pressure line, which discharges into the storage bottles at about 120 lb. pressure began smoking near the high-pressure suction valve. The machine was immediately shut down and nothing was touched for several minutes, or until the pipe quit smoking. Then the pressure was relieved very slowly and the pipe disconnected at the high-pressure suction valve, and at the low-pressure discharge valve, after which the line was blown out until the air became clear. A lot of water and a small amount of oil had accumulated in the line. At first the smoke appeared black, but later changed to blue before it became clear. The machine was down for about twenty minutes. Since then we have had no trouble with overheating or explosions.

My experience with overheated compressors, and other instances that I have had the opportunity to observe, lead me to believe that they are brought on by one or several of the following causes: The accumulation of oil in the line and an excessive amount of carbon; partly obstructed cooling water lines and jackets; too lean lubrication which would cause excessive heat of the pistons; or excessive heat of worn valves and guides. JARRETT LAW,

Casper, Wyoming. Tea Pot Station.

Reminiscences of a Veteran Mechanical Engineer

As a student of the Massachusetts Institute of Technology in 1874 I went on an excursion to Providence, R. I., with our class in Mechanical Engineering. Among the shops that we visited was that of the Corliss Steam Engine Co. We felt when there, as we examined the tools and the steam engines under construction that we were at the Mecca of the steam engine industry made famous by Mr. Corliss.

At this time Mr. Corliss must have been working on his beautiful and famous engine, which attracted so much attention at the Centennial Exposition at Philadelphia in 1876. We were shown the remarkable gear-cutting machine with which was to be cut the teeth of the large spur flywheel and its pinion used on this engine; it was a daring engineering feat to undertake, to build so large a cast-iron gear with cut teeth which was to be operated in such a conspicuous and vital position; but later the quiet operation of these wheels demonstrated the perfection of the workmanship expended upon them. Today it might be interesting to know something of the size and speeds of these wheels, also the type and dimensions of the teeth employed.

We were taken to the Hope Street Pumping Station and saw the interesting multiple-cylinder pumping engine with its vertical shaft, which has already been illustrated and described in the Aug. 14 issue of *Power*. We were not then informed of its serious thermal defect. Indeed, at this time the influence of speed on engine economy was not generally understood. Perhaps this engine, with its indicator cards showing tremendous re-evaporation after cutoff at extremely low speeds, was an eye-opener to engineers, showing as it did that time was one of the factors affecting cylinder-condensation.

Although this engine had the ingenious valve-gear which had made the Corliss engine famous, yet it lacked one of the usual features of his moderate-speed engines which made them so economical; this was the long stroke which produced high piston speeds at these moderate speeds, and perhaps more important, secured small clearance space and surface. There was in Cincinnati, until recently, a real Corliss engine, 16-in. bore by 60-in. stroke, running at about 60 r.p.m., which had been in service about fifty years.

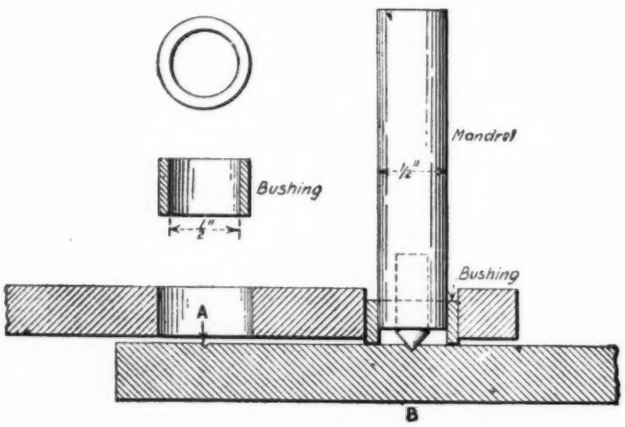
Mr. Corliss appeared to be interested in our work at the institute and sent us home with a problem to solve. He evidently was conducting hydraulic experiments, for at one side of his shop was a tank through which water was flowing; in the side of the tank, about half way up, was a circular orifice, at its base outside were level planks upon which the water fell. He gave us the diameter of the orifice, the height of the orifice above the planks, and the distance from the side of the tank in which the orifice was located to the spot where the stream hit the plank. He asked us, with this data, to determine the rate of discharge from the orifice.

Perhaps we were as much interested in and impressed by the personality of Mr. Corliss himself as by his engines. His tall, erect figure, his keen face, and a certain dignity of bearing were very impressive. I have always considered it a privilege to have seen him and to have had him talk to us as he did that day.

Cincinnati, Ohio. JAMES B. STANWOOD.

Marker for Locating Adjacent Holes

Referring to G. A. Luers' article in the Aug. 7 issue for locating adjacent holes, I do not believe that he has accomplished much. Assuming that the holes to be located are so placed that it will be necessary to use



SHOWS HOW MARKER IS ADAPTED TO HOLES OF DIFFERENT DIAMETERS

some method other than spotting by drilling and using the old holes for a jig, I believe the best method is with the scriber.

Mr. Luers claims that a scribed hole is only an approximate centering circle if a tap-size hole is drilled. There is no reason why the exact size of the hole cannot be obtained or marked if care is used in manipulating the scriber. After the periphery of the circle is marked, one should take a center punch having a small point and prick three or four small centers on this mark. After making these punches take a pair of dividers and locate the center of the circle. This center should be lightly prick-punched and then proved by opening the dividers and seeing if the outer leg absolutely follows the scribed circle. This job may be highly accurate, from the fact that the small punch mark can be drawn over, or shifted, until the compass shows it to be in the exact center of the scribed circle.

If the holes to be drilled are to be the same size as the ones that they were located by, all that will be necessary is to make the center mark deeper and drill through, first using a small drill and then the full-sized one. The reason for using the small drill first is that its small point will follow the prick-punch mark and stay in the center of the circle, while the point of the larger drill will follow the small hole.

If a tap-size drill is to be used, the best plan to follow, after locating the center and proving it, is to set the dividers so that they will make a circle the size of the tap drill and scribe it inside of the first, of course making them both have the same center. A few small prick-punch marks should be made around the edge of this circle because the drill will make a small burr when the lip begins to cut and the prick-punch marks will show if the drill is running out, or drilling off center. If the drill starts off center, it can be brought back by chiseling off a small amount on the opposite side of the hole from which the drill creeps.

To my mind the reason why Mr. Luers has not accomplished much, is that he would have to spend a lot of time making his marker and then when he has used it, he will have to locate the center of his circle and drill it the same as if he had scribed it. If he wishes to go to this much trouble, I would suggest that he make a center punch as shown in the illustration. After setting a piece of tool steel in a mandrel, it should be hardened and ground and pointed in the usual way, also a series of bushings for different size holes should be made. When it is desired to locate adjacent holes, slip the correct size bushing on the mandrel and put it in the hole, as shown at *B*, and the center of the new hole is quickly and accurately located, as at *A*.

Rockland, Mass. BURTON W. WHEELER.

What Happens to Moisture When It Enters the Furnace?

A mild controversy has arisen here among engineers as to what happens to moisture when it enters the furnace, and we should like to hear the solution from someone who knows. One authority, Jos. W. Hays, says: "When a shovelful of wet coal goes into the furnace, the first thing that happens is the evaporation of the surface moisture clinging to the coal. This is followed by the decomposition of the resulting steam into its elements, oxygen and hydrogen. The hydrogen is next ignited and burns back again into water, returning to the furnace the exact amount of heat abstracted in the operation of decomposition. Some of this heat will be lost by radiation, more of it will be discarded to the chimney, and some of the hydrogen may escape without being consumed. There is, accordingly, a net loss by this operation. But there are credit entries also. Combustible gases are being evolved from the fuel. The hydrogen flame assists in igniting them. When water and incandescent coke come into contact with each other, there is an evolution of CO as well as of hydrogen, the oxygen of the water uniting with the carbon of the coal to form carbon monoxide. This gas rises into the furnace chamber and burns with the hydrogen. The area of combustion is extended, and we have a flaming furnace through which no combustible gas can pass in the presence of oxygen without burning."

This is quite easy to take because Mr. Hays gives no figures as to the dissociation temperature and the ignition temperature—that is, the temperature at which recombination takes place—and if we confined ourselves to this one authority all would be well. It is when we study other authorities that trouble begins.

For instance, the "International Library of Technology" states that "hydrogen is a combustible gas

which, when heated to 500 deg. C. (932 deg. F.) become capable of uniting with the oxygen of the air with the evolution of light and heat."

Another authority, Arthur D. Pratt, gives the ignition temperature of hydrogen as 1,130 deg. F.

Dugald Clerk, in talking about dissociation, says: "Most chemical combinations, while in the act of formation from their constituent elements, evolve heat, and as a general rule the greater the heat evolved the more stable is the compound formed. The compound after formation may generally be decomposed by heating to a high enough temperature, heat being one of the most powerful splitting-up agencies known to the chemist. The nature of the decomposition varies with the compound. In many cases the process is irreversible; that is, although heating up will cause decomposition, cooling down again, however slowly, will not cause recombination. In some compounds, however, under certain conditions the process is reversible and recombination occurs on slow cooling." He says, "Dissociation may be defined as a chemical decomposition by the agency of heat, occurring under such conditions that upon lowering the temperature the constituents recombine."

He goes on to say: "Groves found long ago that water begins to split up into oxygen and hydrogen gases at temperatures low compared to that produced by combustion. Deville made a careful study of the phenomena, and found that decomposition commences at 960 deg. to 1,000 deg. C. (1,760 to 1,850 deg. F.) and proceeds to a limitec extent; raising the temperature to 1,200 deg. C. (2,200 deg. F.) increases it, but a limit is reached. The amount of decomposition depending on the temperature; for each temperature there is a certain proportion between the amount of steam and the amount of free oxygen and hydrogen present. If the temperature is increased, the proportion of free gases also increases; if the temperature is diminished, the proportion of free gases diminishes. If the temperature is raised beyond a certain intensity, the water is completely decomposed; if lowered beyond a certain temperature, complete recombination results."

In *Power*, Dec. 14, 1920, it is stated that hydrogen cannot be dissociated from water at ordinary furnace temperatures.

In *Power*, Jan. 4, 1921, R. E. Millar states that he has made thousands of cubic feet of hydrogen with steam at a temperature of 1,000 deg. F. and millions of cubic feet at a furnace temperature of 1,400 deg. F.

In Bureau of Mines Bulletin No. 7, Clement, Adams and Haskins state that with zero velocity the decomposition of water vapor is practically complete at 1,100 deg. C (2,000 deg. F.). With a steam velocity of 0.5 ft. per sec. and a depth of fuel bed of 1 ft. a temperature of 1,300 deg. C. (2,375 deg. F.) is necessary. They state also that at a temperature of 800 deg. C. the amount of water decomposed was always less than 1 per cent.

In "Finding and Stopping Wastes in Modern Boiler Rooms," published by the H.S.B.W. Cochrane Corp. it is stated that "in this connection it may be said that water vapor passed through incandescent carbon at 1,112 deg. F. will result in CO_2 and H_2; at 1,832 deg. F. CO and H_2 will form."

Water or water vapor does not pass through incandescent carbon except in a gas producer or in an underfeed stoker. In the gas producer the supply of oxygen is limited so that a combustible gas may be produced, and in the underfeed stoker we are given to understand that the air is sufficient to produce CO_2. In the hand-fired furnace we understand that CO_2 is formed in the lower part of the fuel bed because there is sufficient oxygen present for the purpose, but that in the upper part of the fuel bed a molecule of CO_2 takes up another atom of carbon to form 2CO indicating that the affinity of oxygen for carbon is greater than the affinity of oxygen for CO_2.

As the ignition temperature of fixed carbon is lower than that of hydrogen, being according to A. D. Pratt, from 766 deg. F. for fixed carbon from bituminous coal to 925 deg. F. for fixed carbon from anthracite, while the ignition temperature of hydrogen is 1,130 deg. F., it would appear as if no hydrogen will be burned as long as there is any unburned carbon provided there is sufficient air present for the combustion of the carbon, but A. D. Pratt says that the hydrogen constituent unites with oxygen before the carbon. We might assume then that when water is decomposed, the hydrogen would unite with the oxygen before the carbon does, but Jos. W. Hays says that when water and incandescent coke come into contact with each other, there is an evolution of CO as well as of hydrogen, the oxygen of the water uniting with the carbon of the coal to form CO.

David Moffat Myers, in a paper on "The Economic Combustion of Waste Fuels," says: How the moisture content of a fuel affects the necessity of mixing the gases is of interest. The moisture is evaporated as steam, a gas, and becomes superheated. The molecules of this non-combustible gas tend to form a separating medium between the molecules of oxygen and those of the combustible gases. Thus moisture increases the opposition to combustion and increases the need and value of assuming a thorough mixing of the gases rising from the fire."

But Jos. W. Hays says that one of the credit entries in favor of moisture is that it improves combustion. In order that the steam may act as a separating medium, it must exist as steam in the furnace, and it is difficult to see how this can be if R. E. Millar is correct when he says that he made hydrogen at 1,000 deg. F. But A. D. Pratt says that the ignition temperature of hydrogen is 1,130 deg. F., so R. E. Millar must have been mistaken about the temperature. The escape of unburned hydrogen would be serious as it requires 6,900 B.t.u. to dissociate 1 lb. of water, and as slow cooling is necessary for recombination, it is difficult to see how such loss can be avoided. The handbook of the H.S.B.W. Cochrane Corp. states that dissociation takes place at 1,112 deg. F., and as the ignition temperature must be lower than the dissociation temperature, this conflicts with the statement that the ignition temperature is 1,130 deg. F. Even if we accept the International Textbook Co.'s statement that the ignition temperature is 932 deg. F., there is not a sufficient margin.

If 1,000 deg. F. is dissociation temperature, as R. E. Millar claims, or 1,112 deg. F. as the H.S.B.W. Cochrane Corp. claims, it is evidently impossible for recombination to take place before the gases enter the tubes of a return-tubular boiler, and then the cooling may be too rapid for combustion.

It should be evident from the foregoing that the engineer who wishes to have peace of mind should study only one authority. But which one? Possibly some reader of *Power* can clear me up on this point.

Toronto, Ont., Canada R. McLAREN.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Trouble Using a New Injector

For feeding the boiler of a traction engine we are having some trouble to use a new injector in replacement of an old one. The injector raises the water, but fails to force it into the boiler. Could the trouble be due to air leaks in the suction hose? C. E. R.

If the injector raises the water, the trouble is not likely to be caused by air leaks, but to clogged condition of the passages of the injector or more likely the feed-pipe connections. Where conditions have been such as to require replacement of an injector, all old connections, especially the feed pipe, stop valve and check valve, should be thoroughly cleaned or replaced by new pipe and fittings.

Taking Leads of Bearings

What is the purpose of taking leads of bearings, and how is it done? R. L. M.

Leads are taken to gage the amount of clearance and determine whether the bearing requires refitting. The method of taking a lead is to remove the cap of the bearing and lay a length of lead wire along the cap or journal, parallel to the axis. The cap then is screwed down hard on the liners and the lead wire is compressed to a thickness equal to the clearance. The lead thus affords means of gaging the clearance and, by comparing it with one previously taken at the same part of the bearing, the difference of their thicknesses indicates the amount of wear that has taken place in the interval and the amount of clearance to be taken up in refitting the bearing.

Pump Pounds from Too Much Suction Lift

We have a 6x4x6-in. duplex boiler-feed pump that takes suction from a sump with the foot valve 16 ft. below the intake of the pump. At present the suction water is considerably lower than usual, leaving the foot valve only about 2 feet below the water surface, and the pump hammers badly at the end of each stroke. Could this be due to lowering of the suction-water level? P. C. H.

Although the actual lift may be only 14 ft., the suction lift probably is increased about three feet by loss of pressure sustained from the passage of the water through the suction pipe, foot valve and other fittings. Referring to the suction-lift diagram, page 69, July 10 issue, it may be concluded that from lowering of the suction-water level the suction lift is too great under the conditions, resulting in incomplete filling of the water cylinders and pounding, and for proper operation, the pump should be lowered about four feet.

Front End of Engine Cylinder

Which is the front end of the cylinder of a horizontal engine? W. R. T.

The end of the cylinder that is towards the crank is commonly called the "front end" and the opposite end is called the "back end" of the cylinder. The terms are not self explanatory unless by assuming that it is consistent with calling the power stroke of a trunk engine the forward stroke. In locomotive practice the nomenclature is the reverse. The end of the cylinder towards the forward end of the locomotive, as natural to expect, is called the front end and a good way to remember which is called the front or back end on stationary engines is to recall that the terms "front" and "back" or "forward" and "backward" are used with the reverse of their natural significance with respect to parts of a locomotive.

To avoid ambiguity, especially in labelling indicator diagrams, it is best to designate the ends of a cylinder as "head end" and "crank end" requiring the simple abbreviation "H" and "C."

Cutting Pipe with Hack Saw

In our plant we are occasionally required to cut iron or brass pipe when it is impractical to use ordinary wheel cutters and must depend on filing or use of a hack saw. The hack saw seems handiest for many purposes if it would not stick and break. How can this trouble be avoided? E. T.

In cutting off a pipe with a hack saw, sticking and breaking of the saw blade is very likely to occur if the saw cut is extended clear through the pipe walls. For making a cut, first make a distinct mark all around the pipe for the length desired, then make a light saw cut all around, leaving the mark stand, and continue the cut to an even depth all around without cutting through the pipe walls more than necessary, until so little stock is left that the pipe end can be broken off by pressure of the hand. Some mechanics prefer using a hack saw to any other method of pipe cutting, as the tool is light and inexpensive and, when properly used is durable, requires little effort and leaves very little burr and without deformation of the pipe. Best results are obtained when the saw blade is held in a low-back frame and the saw has about 24 points per inch.

Leakage Through Boiler Blowoff Cock

After washing out two of our boilers and refilling them with water to the tops of gage glasses, in eight hours there was a leakage of 340 gal. of water through leaky blowoff cocks. The amount was measured by

metering the quantity of water required to refill the boilers to the same water level. What would the leakage amount to in eight hours with the boilers under steam pressure at 75 lb. gage? M. W.

The rate of leakage for small variations of head would be approximately in proportion to the square root of the average pressure. Assuming that the average head of water acting on the aperture of the blowoff cock is 9 ft., the average pressure would be $9 \times 0.433 = 3.99$, or practically 4 lb. per sq.in. gage. With the steam pressure at 75 lb. gage the average pressure would be $75 + 4 = 79$ lb. per sq.in. gage. Then, if the water level is the same and the counter-pressure on the discharge side of the blow-off cock in each instance is no more than the pressure of the atmosphere, the velocity of discharge under steam pressure would be to the velocity with a cold boiler as $\sqrt{79}$ to $\sqrt{4}$, or about 4.45 times as much, and in the equal time of eight hours under 75 lb. boiler pressure, the leakage would amount to $340 \times 4.45 = 1{,}513$ gallons.

Difference in Glass Gages on Same Boiler

We have a 5,000-sq.ft. water-tube boiler with two steam drums each provided with a glass gage and one gage frequently shows six or seven inches lower water than the other. The mountings are clear. What causes the gages to indicate different water levels? H. L.

On account of disturbance of the boiler water by circulation and ebulition, a glass gage rarely shows the average water level and gages connected to different parts of the boiler usually give different indications. In water-tube boilers the difference may result from unequal intensity of the fire on different parts of the grate, or unequal distribution of heat over the tubes from a forced draft, or from unequal freedom of passages of escape of steam from the water space to the steam drums; or difference in relative location of the water-column connections.

Water Sealing of Pump Stuffing Boxes

Why are pump stuffing boxes water-sealed, and how is it accomplished? W. L. B.

Water-sealed stuffing boxes are used on the piston rods of pumps employed to obtain a high vacuum, to prevent leakage of air into the pump cylinders. The

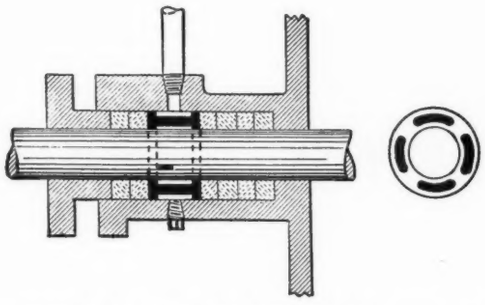


FIG. 1—WATER-SEALED STUFFING BOX WITH LANTERN

water sealing consists in keeping the piston rod surrounded with water to make airtight joints between the rod, packing and stuffing box. An ordinary stuffing box, if long enough, can be water-sealed by inserting a "lantern" or frame of the form indicated with black cross-section, Fig. 1. As shown by the sectional view of the stuffing box, the first four rings of the stuffing-box packing are placed in the box, then the lantern, then two more rings. The lantern acts like a skeleton washer to separate the sets of packing rings, leaving a space around the rod that is connected to the discharge chamber of a water pump or other source of water supply. This prevents air from leaking through the stuffing box when it is only tight enough to prevent leakage of water. Other forms of water-sealed stuffing

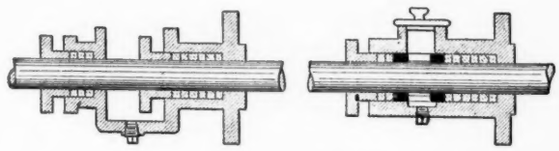


FIG. 2—WATER-BOX TYPE STUFFING BOX FIG. 3—COMBINED BOX AND LANTERN
FORMS OF WATER-SEALED STUFFING BOXES

boxes are shown in Figs. 2 and 3. Fig. 2 illustrates a common form with an open water box and two stuffing boxes and Fig. 3 illustrates a form that combines features shown in Figs. 1 and 2.

Effect of Reduced Size of Valve in Water Pipe Line

Our water supply is obtained from a small reservoir by a 6-in. pipe line under a total head of about 50 ft. and there is a 5-in. gate valve in the line near the discharge end. The valve is left wide open except when it is desired to shut off the whole supply. From use of this size of valve, is not the delivery reduced to the equivalence of a 5-in. pipe line? R. T. H.

In long pipe lines, the loss of head from pipe friction is so great that, in many cases, the restriction of the flow from use of a stop valve a size smaller than the pipe size is scarcely perceptible. For discharging the same quantity of water in a stated time, the additional loss of head, sustained to obtain the greater velocity required through the valve of smaller aperture, may be only a small fraction of the total head available.

The loss of head from use of a 6-in. gate valve is about the same as the resistance of 80 ft. of 6-in. pipe, and use of a 6-in. valve would make the loss of head about the same as the loss of head by friction in a 6-in. line $1{,}200 + 80 = 1{,}280$ ft. Assuming delivery at the rate of 500 gal. per min., the velocity head would be 0.5 ft., entrance head 0.25 ft., and loss of head from pipe friction, computed from Darcy's formulas, about 29.7 ft., or a total loss of 30.45 ft., leaving $50 - 30.45 = 19.55$ ft. head available for discharge pressure.

When discharging at the same rate, 500 gal. per min., using a 5-in. valve, the resistance would be the same as for a pipe line consisting of 1,200 ft. of 6-in. pipe and 60 ft. of 5-in. pipe. The head required for necessary velocity through the 5-in. valve would be about 1 ft., head lost at entrance to the 6-in. pipe 0.25 as before, head lost by discharge through the valve would be about 5.5 ft. and head lost in friction in 1,200 ft. of 6-in. pipe 27.87 ft. or a total of 34.62 ft., leaving $50 - 34.62 = 15.38$ ft. head available for the pressure of the discharge. If the pipe line were 5 in. throughout the total available head of 50 ft. would be absorbed in overcoming pipe friction for a flow of about 400 gal. per min., delivered without head.

Easy Lessons in Engineering

The A B C of Heat Balance

While "heat balance" is a fairly old expression in power-plant engineering, it is only in recent years that it has come into every-day use. To understand the expression it is important to know that it has two meanings. When used in its original meaning, heat balance is merely a kind of bookkeeper's "balance sheet" in which B.t.u. are substituted for dollars and cents. Such a sheet, showing how energy is distributed, can be prepared for any kind of power plant or any piece of power-generating or power-using apparatus.

While, in recent years, the old meaning of heat balance has been retained, another meaning has been added. In this new sense heat balance means a *good* heat balance, that is such an arrangement of the apparatus that as little heat as possible goes to waste. In particular, it refers to arrangements where no exhaust steam is allowed to go to waste and where the maximum amount of work is first taken out of each bit of steam later used for heating feed water.

The present article will be confined entirely to a discussion of heat balance in its original sense. In this sense every plant, good or bad, has a heat balance, just as a balance sheet may be prepared for any kind of a business. There is no hard or fast rule as to how this must be expressed, except that all the energy supplied must be accounted for.

As a simple and rather crude example, take the case of a cheap portable engine and boiler for hoisting, the boiler being fed with an injector. Suppose the data for twenty-four hours operation (including the banked period) is as shown in Table I. The figures in the second column give the weight and engine output corresponding to one pound of coal. The smaller figures thus obtained are easier to handle than the totals for twenty-four hours or for one hour. In this preliminary study, we will not try to analyze all the losses, but lump them for each piece of apparatus.

TABLE I—ECONOMY DATA OF STEAM HOISTING OUTFIT

	Total for 24 Hr.	Per Lb. of Coal
Average steam pressure, lb. gage	100	.....
Average temperature of feed water, deg. F.	60	.....
Average heating value of fuel, B.t.u. per lb.	13,500	.....
Weight of coal burned, lb.	830	1
Weight of water fed to boilers, lb.	4,450	5.36
Steam and water lost from boiler, lb.	350	0.42
Weight of steam delivered to engine, lb.	4,100	4.94
Work performed by engine, horsepower hours	73	0.088

First, it is evident that the principal input of the boiler is the 13,500 B.t.u. in 1 lb. of coal. The only other heat coming to the boiler is in the 60-deg. feed water. The boiler feed water at 60 deg. contains (above 32 deg.), 60 — 32 = 28 B.t.u. per lb., or a total of 5.36 × 28 = 150 B.t.u. So the total heat coming into the boiler is 13,500 + 150 = 13,650 B.t.u. The steam delivered to the engine contains 1,189 B.t.u. per pound, or a total of 1,189 × 4.94 = 5,874 B.t.u. The total boiler loss must therefore be 13,650 — 5,874 = 7,776 B.t.u.

Of the 5,874 B.t.u. delivered to the engine, only a small amount appears as power. The heat equivalent of 1 hp.-hour is 2,545 B.t.u., so the heat equivalent of the 0.088 hp.-hr. produced by the engine per pound of coal fired will be 0.088 × 2,545 = 224 B.t.u. The engine must therefore waste, through the exhaust and elsewhere, 5,874 — 224 = 5,650 B.t.u.

The heat balance is now really completed, but it should be tabulated in some striking form for the sake of clearness. One possible form is shown in Table II. In this the input and output are arranged in separate columns for each element of the power plant. The B.t.u. column should be carried through first. Note that the total output, including losses, must in each case equal the total input. To fill in the per cent columns, take the 13,500 B.t.u. in one pound of coal as 100 per cent. Then any per cent is to corresponding B.t.u. as 100 is to 13,500. This proportion is easily solved and permits filling in all of the per cent columns.

TABLE II—HEAT BALANCE OF HOISTING OUTFIT

	Input			Output		
Apparatus		B.t.u. per Lb. of Coal	Per Cent of Heat in Coal		B.t.u. per Lb. of Coal	Per Cent of Heat in Coal
Boiler	Heat in coal	13,500	100.0	Heat in steam	5,874	43.5
	Heat in feed water	150	1.1	Boiler losses	7,776	57.6
	Total	13,650	101.1	Total	13,650	101.1
Engine	Heat in steam	5,874	43.5	Power output	224	1.7
				Engine losses	5,650	41.8
	Total	5,874	43.5	Total	5,874	43.5

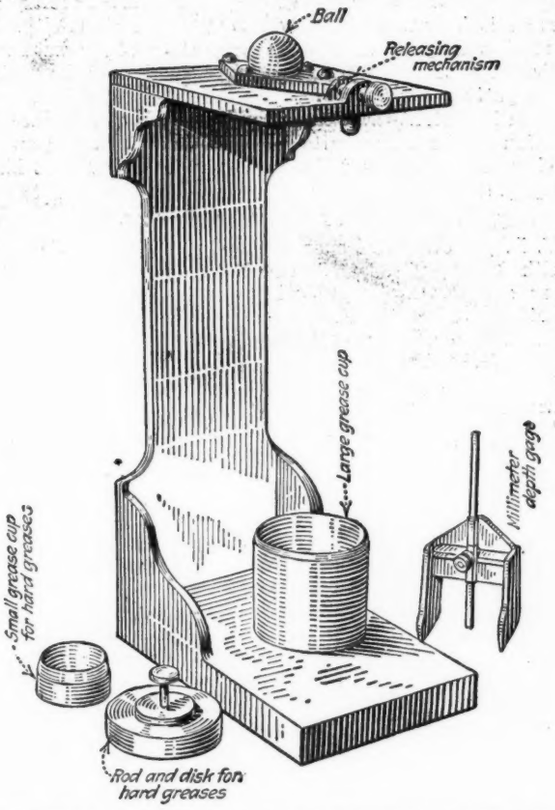
In this case it is evident that, since 13,500 B.t.u. is equivalent to 100 per cent, 135 B.t.u. must be equivalent to 1 per cent. So the items in the per cent column may be filled out by dividing the corresponding heat values by 135.

The example chosen was unusually simple. Moreover all of the boiler losses were lumped together. The same applies to the engine losses. In the more complicated heat balances these may be separated as much as desired. Future lessons will go more into detail in this matter.

From the method of the table's construction the totals necessarily balance even if the original data are all wrong. If all the boiler losses had been determined by actual measurement instead of by the simple process of subtracting the useful output from 13,650, the chance of the sum of these losses and the useful output totaling exactly 13,650 would have been remote. Therefore another item (plus or minus as need be) just sufficient to bring the total to 13,650 would be added. This item would ordinarily be labeled "unaccounted for" and represent the total of all errors and omissions. The smaller this item the better the quality of the work. Even in a high-class boiler test it is hard to keep this item under two or three per cent.

New Grease-Testing Apparatus

A new type of apparatus for determining the consistency of greases was described in the July number of *Industrial and Engineering Chemistry*. This apparatus, which is shown in the accompanying drawing, was developed by Charles B. Karns and Oscar L. Maag, of the Research Laboratories of the Galena Signal Oil Company, Franklin, Pa., for the accurate determination of the consistency or solidity of lubricating greases, both hard and soft. The apparatus is so constructed that by pressing a trigger, a ball of definite weight and diameter is released and falls a specified distance into the center of a standard cup containing the grease to be tested. The depth of penetration is measured in millimeters by a depth gage and recorded



PENETRATION OF FALLING BALL MEASURES CONSISTENCY OF GREASE

as the consistency or degree of solidity of the grease. For lubricants that are too hard to be measured in this manner, such as hard greases for railroad lubrication, the ball falls upon a pin, which is held by a disk supported by the large cup centrally above the sample of hard grease contained in the small cup. The penetration of this pin is measured in millimeters and recorded as the consistency. Consistencies determined by the ball falling directly into the grease are denoted by *scale S*, while readings taken with the pin are designated by *scale H*. A temperature of 75 deg. F. has been found suitable for determining the consistency of most greases.

A study of the heat effect of corrosion of the monel-metal combustion bomb, as related in a paper by J. C. Geniesse and E. J. Soop before the American Chemical Association, showed that coals having sulphur contents varying from 1.76 per cent to 5.76 per cent gave errors running from 0.50 per cent to 1.75 per cent. If the bomb washings are titrated for free acid and if it is assumed that the rest of the sulphur unites with the bomb to form nickel and copper sulphates, the errors may be reduced to less than 0.3 per cent. The errors were determined by comparing a monel-metal bomb with a gold-lined bomb and by analyzing the bomb washings for copper and nickel.

Testing Each Boiler Continuously

David Brownlie, who has for years been hammering away on the important subject of day-in and day-out boiler efficiency as distinguished from efficiency obtained on special tests, had more to say along this line in a recent issue of the *Electrician* (London). His article, entitled "Efficient Steam Production," states that British engineers in general are still far from appreciating the importance of keeping a daily record of the items that enter the boiler-plant efficiency, and particularly of the efficiency of each individual boiler. By installing suitable instruments for each individual boiler and hiring a trained expert whose sole duty it would be to give scientific attention to the efficiency of the boiler plant, the efficiency of the average British boiler plant could, he believes, be raised from 67½ per cent to 77½ per cent, figured on a yearly basis. The following extract is of particular interest:

One thing I can never understand is the amazing reluctance, coupled, if necessary, with determined and relentless opposition, both by the average power-station engineer and the members of the electricity committee, who, of course, generally know nothing about the matter anyway, to paying a man to do nothing else but attend solely to the efficiency of the power plant in a scientific manner. The idea of paying some one, say £10 or £15 per week to do "nothing but look after boilers" always strikes the ordinary person as a wicked and wanton waste and a gross extravagance. I must say the exact psychological reason of this fairly beats me, especially in view of the fact that in most large stations it would even be a paying proposition to have a whole row of university professors at £1,000 per annum each, one to every boiler.

Mr. Brownlie goes on to say, however, that there is evidence of some improvement, particularly in the matter of automatic weighing of the coal to each boiler, which is now fairly common in the newer British stations. In this connection he suggests the use of some automatic arrangement, whereby a few pounds of coal could be shot out into a small storage bin at fifteen-minute intervals, so as to give at the end of the day a representative sample of the coal used. The sampling device could be combined with a small mechanical mixing and crushing apparatus, so that the daily samples from each boiler—to the extent of several hundred pounds—could be mixed and crushed without trouble and a small sample of several pounds taken for the laboratory. The bomb calorimeter would be used for determining the heating value of the coal, and a muffle furnace for the ash determination.

While discussing coal measurement, Mr. Brownlie stresses the equal importance of measuring the feed water and says that the difficulty of so doing is much overestimated. He also recommends the installation on each boiler of machines for automatic gas analysis and of distant-reading pyrometers, and concludes his article with the statement, "I can only say again, finally, that the best results will not be obtained until each boiler is rigidly regarded as an entirely separate and independent unit."

This is the key to the whole article. The idea is that unless figures are available for each boiler separately, it will be impossible to locate and correct the cause of any falling off in efficiency.

Previous attempts to measure the loss in heat value of coal during storage have yielded varying results owing to changes in weight of the coal due to oxidation and owing to the difficulty of obtaining exactly representative samples. An experimental method used by John F. Byrne and J. D. Davis, and described in a paper before the gas and fuel section of the American Chemical Society, consisted in accurately weighing duplicate portions of coal (both being of weight suitable for calorimetric determination) from the same sample, subjecting one portion to oxidation and immediately determining the heat value of the other. The heat value of the oxidized portion as compared to that of the first was then exactly obtainable, irrespective of any loss or gain in weight during the oxidation process. Loss in heat value varied from 0.02 per cent to 0.6 per cent for coking coals under various conditions prevailing in the tests.

N.A.S.E. Holds Annual Convention

THREE HUNDRED AND EIGHTY-SIX official delegates and over twice that number of guests and manufacturers' representatives took part in the forty-first annual convention of the National Association of Stationary Engineers at Buffalo last week. Monday was devoted largely to registration, the opening of the mechanical exhibit in the Broadway auditorium and to a reception by National President Felderman in the evening at the Hotel Lafayette. The official opening of the convention took place Tuesday, with addresses by E. P. Gilroy, of the local convention committee, J. M. Howie, representing the Chamber of Commerce, President Felderman, Vice-President Holbrook and Past-President Parry.

Urges Care in the Selection of Officers

The two outstanding recommendations in President Felderman's address at the afternoon session were a plea for greater care in the selection of officers for state and subordinate committees and greater attention to educational features that will develop engineers to cope with the new order of things in the power-plant field. "Many associations," he said, "pay too much attention to good fellowship without regard to any qualifications that are essential to leadership, or a man may be chosen to please the membership of a certain locality without possessing the necessary qualifications, and as a result all the good work of his predecessor goes for naught." Moreover, with regard to committees, Mr. Felderman said that it is not for the best interest of the association that the committees be changed yearly, but rather that the tenure of office of certain committees should be such that the personnel is changed by retiring one member each year.

Vice-President and National Deputy Holbrook reported that the Association now has an active membership of 19,181, there having been 2,410 initiated and 2,075 members lost during the year. He took occasion to mention the small average attendance at meetings of the subordinate associations and cited the figures for the previous year as given at Des Moines. This showed an average of only 6.63 per cent. During the past year these figures have remained practically the same. He suggested further that the membership records be filed with the national secretary to obviate their being lost from constant changing of local secretaries.

The Educational Committee reported awards to the following members as prizes for the best answers to the 45 questions published a short time ago in the *National Engineer:* First prize of $150 to John W. Ruppert, of Bloomfield, N. J.; second prize of $75 to Robert A. Torstensen, of Cambridge, Mass.; third prize of $50 to G. T. Krosse, of Peoria, Ill.; fourth prize of $25 to F. W. Horn of Milwaukee, Wis.

The delegates and guests listened on Tuesday evening to three most instructive talks on fire prevention. These were illustrated by both lantern slides and moving pictures. Mr. T. Alfred Fleming, of the National Board of Fire Underwriters, said that last year's toll of fires was over 14,000 persons killed and 16,000 injured, in addition to a property loss of $521,000,000. Of these fires 92 per cent were preventable. Moreover, our fire rate is fourteen times the average for all European countries. With reference to the special hazards that concern the engineer, he discussed the location of boiler rooms, coal storage, oil storage, improper installation and handling of electric circuits, and dust explosion caused by sparks from static electricity. He was followed by Ira G. Hoagland, secretary of the Automatic Sprinkler Association, who illustrated the use of the sprinkler in putting out fires in the incipient stage when time is such an important factor. George B. Muldaur explained the function of the Underwriters Laboratory and by means of moving pictures showed the actual testing of various kinds of equipment.

Storage of Bituminous Coal

W. L. Abbott, chief operating engineer of the Commonwealth Edison Co. of Chicago, delivered an instructive paper on "Coal Storage." It will be recalled that Mr. Abbott is chairman of the committee representing the Federated American Engineering Societies which is making a nation-wide coal-storage survey in co-operation with the United States Coal Commission and the Department of Commerce. During last year's coal strike, said the speaker, coal consumers of the country probably paid $200,000,000 more for their coal than would be necessary had a reasonable storage been provided, but at that the price was perhaps $100,000,000 less than what they would have had to pay had no storage been available. He pointed out that coal storage at the mines would not serve the purpose inasmuch as it would be at the mercy of labor troubles, and recommended that storage by the consumer be at least enough to carry over a period of three months. He cited figures to show that in a large plant adequate storage can be provided at an investment charge amounting to about 17½ cents a ton and that the rehandling should not exceed 15 cents a ton. For smaller plants the cost of rehandling might run as high as 75 cents a ton.

An offset to the storage charge might be effected through the introduction of preferential summer freight rates on coal. This the railroads could well afford to do inasmuch as it costs them less to haul in summer than in winter.

Disintegration of coal takes place largely on the surface, but its effect on the heat value is trivial. Spontaneous combustion can be reduced to an almost negligible factor by properly storing the coal. In this connection Mr. Abbott pointed out that the liability of spontaneous combustion is

DELEGATES, GUESTS AND EXHIBITORS REPRESENTATIVES

ONE HUNDRED FORTY EXHIBITORS OCCUPIED BOOTHS IN THE CONVENTION HALL

almost in direct proportion to the amount of surface exposed. In fine sizes there is relatively more surface exposed than in large lumps, therefore if all the coal to be stored could be kept larger than that which would pass through a one-inch mesh and the depth of coal piles could be kept under ten feet, the problem of spontaneous combustion could be easily handled.

The social features of the convention consisted of a boat trip to Crystal Beach, a theater party for the ladies, visits to important plants in and around Buffalo, an entertainment by the Exhibitors Association Thursday evening and the grand ball at the Hotel Lafayette on Friday evening. The following officers were elected for the ensuing year:

President, Royal D. Holbrook, Cedar Rapids, Iowa; vice-president, Dudley G. Kimball, Cambridge, Mass.; treasurer, Samuel Forse, Pittsburgh, Pa.; secretary, Fred W. Raven, Chicago, Ill.; conductor, James S. Heath, Elizabeth, N. J.; doorkeeper, J. K. Marquis, Knoxville, Tenn.; trustee, Jose F. Carney, New York City.

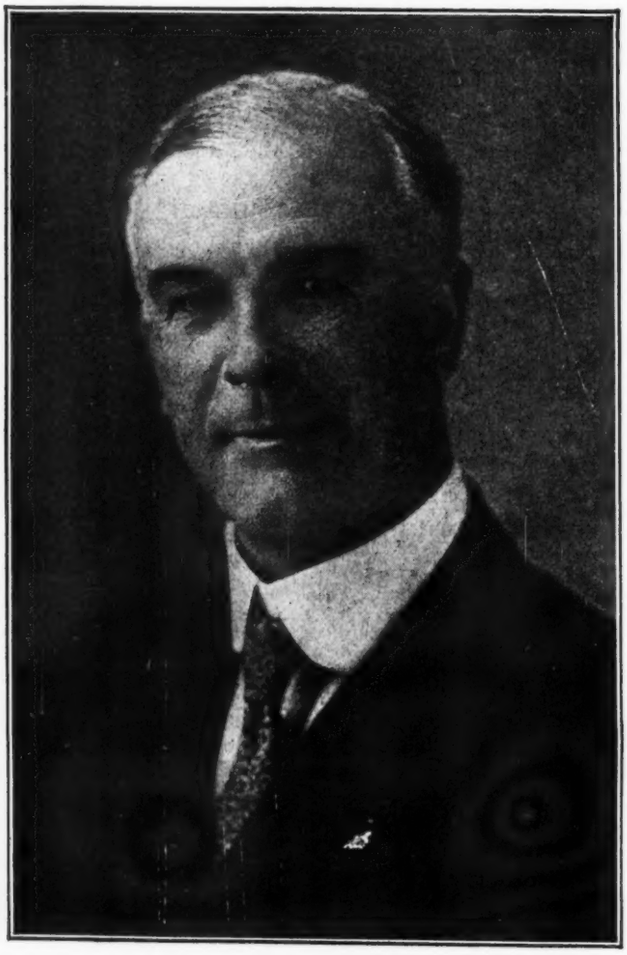
Grand Rapids, Mich., was chosen as the place for holding the annual convention of 1924.

State Conventions Precede the National

On Sunday preceding the national convention both the New York and the Pennsylvania State Associations held their annual meetings at the Lafayette Hotel. Hon. Frank C. Perkins, Commissioner of Public Works of Buffalo, addressed the New York meeting on behalf of the city and strongly advocated the production of electricity by the municipalities. He pointed out that the engineer is an essential asset in the efficient generation of power, especially that produced in the superpower plant. To this statement

ASSEMBLED IN FRONT OF THE BROADWAY AUDITORIUM

Vice-President Holbrook replied by pointing out that a past president of the N.A.S.E. was responsible for the development of one of the largest superpower stations in Indiana. Organization problems were discussed by State President Smith, and Messrs. Fagnan and Sterling discussed educational work. Niagara Falls was chosen as the



ROYAL C. HOLBROOK OF CEDAR RAPIDS, IOWA, NEWLY ELECTED PRESIDENT OF THE N.A.S.E.

next convention city, the following state officers were elected:

President, Andrew S. Bennett; Vice-President, George Sterling; Secretary, W. T. Meinzer; Treasurer, William Downs; Conductor, Louis Hoffman; Doorkeeper, Joseph N. Gregory.

The officers chosen for the Pennsylvania State Association for next year were: President, Jacob F. Mooney; Vice-President, F. J. McCarren; Secretary, J. N. Calvert; Treasurer, Edw. J. Burke; Conductor, J. L. Gnan; Doorkeeper, Ernest Uff.

The Present-Day Diesel Engine

Starting from the paper which he delivered in 1911 on the development of the Diesel engine at that time, Professor Nagel, in an address before the *Verein Deutsche Ingenieure*, at Berlin, June 29, 1923, traced the further development of this prime mover since that time. The four fundamental lines of development cover: (1) The design of the engine and its adaption to economy of material and high number of revolutions; (2) the introduction of the two-cycle process instead of the four-cycle process; (3) the change from the compressed-air injection of fuel to the solid or mechanical injection; (4) new measures for obtaining combustion of heavy combustibles in the Diesel engine.

Referring to the first point, the paper discussed the new design of the engine frame. Valuable experience has been gained from the high-speed submarine engine, which has been more or less utilized in the construction of all present-day Diesel engines. In the construction of the Diesel engine the low costs obtainable by large lot production is desirable. As far as the large engines are concerned, economy of construction materials and of floor space, maintaining at the same time security on service and thermal efficiency, are of paramount importance.

Valve-Scavenging Engines

In adapting the two-stroke-cycle-principle to large units, the valve-scavenging method was the starting point, followed by the slot-scavenging engine. The speaker mentioned the 12,000-hp. two-stroke-cycle Diesel built by the Nuremberg workshop of the Maschinenfabrik Augsburg-Nurnberg for the German Admiralty in 1910, which engine after successful and highly promising trial runs, was destroyed in accordance with the terms of the peace treaty. The Germaniawerft took up the construction of the valve-scavinging engines, this shipyard having constructed the well-known tankship "Zoppot," equipped with two 1,700-hp. two-stroke-cycle engines. In changing over to the slot-scavenging engine Sulzer of Winterthur and Ludwigshafen has rendered pioneer's services; this concern has supplied units of this design up to 3,000 hp. Excellent trial results have been obtained with an entirely new engine of the Sulzer's Ludwigshafen works, placing the two-stroke-cycle engine, as far as the fuel consumption is concerned, on the same level with the four-stroke-cycle. The Augsburg establishment of the Maschinenfabrik Augsburg-Nurnberg, after a long trial work, has recently developed a new two-stroke-cycle method intended for double-acting cylinders of large dimensions.

The small compressorless, or solid-injection, engine has become of great importance and has taken a corresponding many-sided development. The omission of the compressor has become an economical necessity for the small engine, and many claim that the large Diesel engine will ultimately be built without a compressor.

The utilization of heavy tar oil in the Diesel engine has been neglected in Germany since the price of the coal-tar oil has not been enough less than the price of the gas oil and brown-coal tar oil to justify any applications of the hard-boiling coal-tar oil. The chief advance other than the knowledge of the two-stroke-cycle engines being especially well fitted for the safe utilization of hard-boiling combustibles is the two-piece piston design developed by Messrs. Krupp, during interesting trials made in the Essen works. This has proved to be an excellent means by which coal-tar oils may be used even at no load.

The lecturer finally mentioned the application of the Diesel engine to the drive of locomotives and explained the solution of this problem brought about by the use of the Lentz hydraulic gear.

Honor Thirty-fifth Anniversary

Louis A. Ferguson, vice-president of the Commonwealth Edison Co., Chicago, was honored by his associates, at a dinner given at the Drake Hotel on Sept. 12, to commemorate his thirty-five years of service with the company and its predecessors.

After graduating from the Massachusetts Institute of Technology, Mr. Ferguson entered the employ of the company as an inspector, and through loyal and aggressive service he has reached his present position. Within the organization he has been a popular executive and as an evidence of his standing in the profession he has the rare distinction of having been elected to the presidency of the three leading electrical associations of the country, namely, the American Institute of Electrical Engineers, the National Electric Light Association and the A. E. I. C. About 300 men who had been associated with Mr. Ferguson, for ten years or more, attended the banquet. Presentation was made of a silver service together with a morocco-bound book containing the signatures of the donors.

News in the Field of Power

Ford To Reconsider Bid on Muscle Shoals

Upon a request from government officials, Henry Ford, his son and engineers who have handled the negotiations for Muscle Shoals, are considering the amending of the bid for a long-term lease of the Muscle Shoals hydro-electric project which will eliminate the Gorgas steam plant on the Warrior River. Mr. Ford formerly declined on several occasions to amend his proposals so as to exclude the Gorgas plant. His desire evidently is to have an auxiliary steam plant where coal may be obtained the cheapest, and Gorgas is at the mouth of mines on the Warrior. It is pointed out, however, that coal could be floated down the Tennessee River to an auxiliary plant at Muscle Shoals itself at very low cost for transportation.

The Alabama Power Company acting under the terms of the contract between it and the federal government when the Gorgas steam plant was extended by the government during the war, has notified the War Department formally that it desires the government to vacate this property and has offered to pay $3,000,000 for that portion of the plant which was built by the government. According to informal statements of high officials of the administration, this price is considered fair.

Mr. Ford will have until Nov. 1 to modify his bid, it is said, though the Alabama Power Co., desires an answer by Sept. 24 and also that the government vacate the Gorgas plant by Oct. 14.

Union of States Greater Than Any Other Union Says Coal Commission

Report on Civil Rights Blames Both Operators and Miners for Strife in the Coal Industry

THE Federal Coal Commission last week released, for publication on Sept. 10, its report on the causes of strikes in the coal-mining industry, dealing largely with the question of civil liberties. This report was received as one of the most important which has been issued by the Commission.

While declaring that numerous statements and affidavits have been submitted, by both sides, regarding denial of rights by one side or another in disputes in the industry, the Commission does not attempt to decide as between the miners and the operators but asserts that at times one side is to blame and in other cases the other. While theoretically there is an open shop in the mining industry, the Commission finds in its report that in actual operation the open shop of the non-union operator is a closed shop to union labor, and that where the union is able to do so, its members refuse to work with non-union men. The report discusses the Herrin massacre at considerable length and also takes up conditions in West Virginia and in parts of Kentucky where considerable violence has occurred.

In its conclusions the Commission recommends that certain standards be adopted under which controversies affecting them should be submitted to voluntary arbitration, and that the standards should be worked out by the operators and the miners and included in their contract. The state should protect the right of a man to work where he chooses and under terms satisfactory to himself, the report states, and while the right of men to combine for collective bargaining is recognized, the Commission declares that none should be forced or intimidated to join the organization. On the other hand, the report says, no corporation should be permitted to break up an organization of labor other than by argument and advice. Wages should be sufficient to maintain the American standard of living, but the Commission makes plain in this assertion that it does not give its approval to any particular current estimate of its cost or that any stated income will insure such a standard.

"The general public, commonly called the consumer, has a right to demand of its government that it shall not freeze in the midst of an abundance of coal," the report states. "Unless, therefore, the capital and labor invested in this industry shall of its own volition adopt methods that will furnish to the public coal when needed, an outraged public sentiment will furnish the supply by either the Army or the penitentiary."

The Commission recommends that while negotiations are pending looking to a new contract, the President of the United States, sixty days before the date, be informed of the facts and principles of the controversy and should appoint some disinterested person to make a report on these facts so that the public may be informed and properly place the blame.

An important recommendation of the report is that Congress should enact such laws as to compel full publicity from both operators and United Mine Workers upon forms prepared by some governmental agency. The Commission gently suggests that well-intentioned persons who know nothing of the local conditions might do well not to go into certain localities and make speeches, regardless of their unquestioned right under the law and the Constitution to do so, as such matters frequently stir up trouble.

In concluding its report on this subject, the Commission says: "The legislative, judicial and executive branches of this government must not permit a union of operators, a union of miners, nor a union of both to become greater than the Union of the States."

The Commission condemns the practice in certain localities of mine operators paying the salaries of officers of the law. It likewise condemns attempts of certain representatives of the United Mine Workers to intimidate men into joining the union.

Power Commission May Deny Application of Louisville

A recommendation was submitted to the Federal Power Commission by its engineering staff that the application of the City of Louisville, Ky. for a preliminary permit to develop a hydro-electric project on the Ohio River near that city be disapproved and that the application of the Louisville Hydro-Electric Co. covering the same site be granted. The conflicting applications regarding this proposed development have been before the commission a little more than a year.

The Louisville Hydro-Electric Co., whose application for a preliminary permit is viewed with favor as contrasted to that of the City of Louisville, is a subsidiary of the Louisville Gas & Electric Co., which in turn is controlled by the Byllesby Corporation, as is stated in the July 24 issue of *Power*.

In their letter the members of the engineering staff state that after studying the conflicting applications on the project and the briefs and documents submitted by both applicants, they have decided to recommend to the commission that the city's application be rejected on the grounds that the water-power project is not an attractive one from an investment point of view, that it is important as a conservation project to conserve coal, but that it will not reduce the cost of electric power in the region materially, if at all.

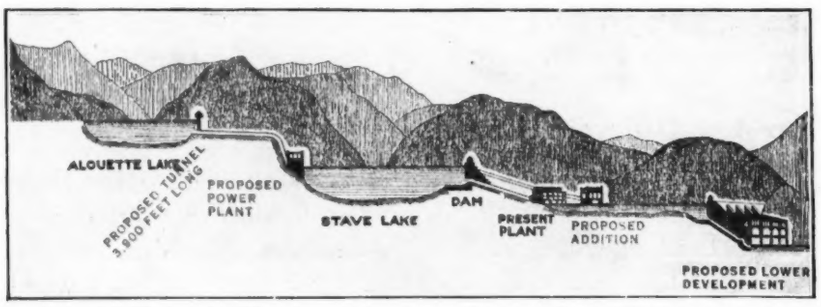
The letter sets forth that the project cannot be developed excepting with auxiliary power of approximately equivalent capacity, 75,000 to 100,000 hp., and that the Louisville Gas & Electric Co. now has its steam development to serve

that purpose and that the city's proposal to develop auxiliary power on the Green River would be an unjustifiable duplication of facilities for which the consumer would have to pay. It is further set forth that for reasons of economy, the hydro plant and the steam plant should be controlled and operated by the same concern.

If the city were able and willing to take over the properties of the Louisville Gas & Electric Co., including its distribution system, then it would be clearly entitled to the preference in the water-power act set forth for municipalities; otherwise the proposal is not in accord with the best scheme of development, the letter further states. A study of the charter of the City of Louisville, the communication sets forth, shows that the municipality can now bond itself to the extent of an additional $14,000,000, but it is stated that to build a hydro plant and take over the properties of the Louisville Gas & Electric Co. would involve $25,000,000 to $30,000,000 and that to get authority to bond itself to this extent it would be necessary first to secure an amendment to the constitution of the State of Kentucky, with consequent great delay even if this could be accomplished.

It is further stated that the power project is feasible only as an adjunct to navigation development in the Ohio River and that this navigation development must be started within the next year, since it is part of the remaining gap to provide 9-ft. navigation in the Ohio from Pittsburgh down. Speed in settling the question, therefore, is essential so that the permittee can work out with the War Department the best project for power and navigation at the proposed site, the letter states.

The Commission has fixed Sept. 24 as the date for a hearing requested by the City of Louisville and meanwhile final execution of the permit to the Louisville Hydroelectric Co. has been suspended, pending this last effort of the city.



PRESENT AND PROPOSED HYDRO-ELECTRIC DEVELOPMENTS ON STAVE LAKE AND ALOUETTE LAKE IN BRITISH COLUMBIA

B. C. Electric Railway Co. Plans Development

A concrete sluice dam under construction by the British Columbia Electric Railway Co., to increase the storage of Stave Lake, is nearing completion and will be ready to store the waters from the early fall rains. The dam will be 60 ft. in height and will increase the storage of the lake from 168,000 acre-feet to 465,000 acre-feet. A fourth generating unit of 9,000-kva. capacity was installed in the Stave Falls plant late in 1922 to utilize the additional water supply made available by the new dam. The Stave Falls plant now has a capacity of 36,000-kva. and if plans for additional development in this vicinity are approved, a fifth unit of 25,000 hp. will be added. Owing to the increase in elevation of Stave Lake by the new dam, it has been necessary to raise the Blind Slough Dam, immediately above the Stave Falls plant, 22 feet.

An application is now pending before the provisional government of British Columbia for the appropriation of the waters of Lake Alouette, lying above and nearly parallel to Stave Lake. If permission is granted, water from this lake will be utilized in a 10,000 hp. plant under a head of 140 ft. Later, a third plant will be built near the junction of the outlet to Stave Lake and the Fraser River, which will develop 80,000 hp. An expenditure of $10,000,000 over a period of from five to ten years is contemplated by this program. Two hydro-electric plants on Lake Buntzen having a combined capacity of 84,000 hp. are now in operation by the company in addition to its Stave Falls plant and a 17,000 hp. stand-by steam station in Vancouver.

President Accords Pinchot Great Credit

Although high government officials generously accord full credit to Governor Pinchot, of Pennsylvania, for successfully bringing together the anthracite operators and miners, there is no disposition to forecast the effect of the agreement by which operations in the hard coal fields are to be resumed.

There is no doubt that the bituminous operators have proceeded energetically in a campaign to sell soft coal to New England in much greater volume. However, the campaign of education of the people in the uses of substitutes for anthracite, which was planned by both federal and state officials has not been put into full effect, and in view of the prejudice of large numbers of the consumers against any fuel other than anthracite, it is problematical how many will turn from this accustomed fuel, now that a supply will be available, provided the price is not advanced sharply.

It was stated at the White House that President Coolidge felt that the Pennsylvania executive had performed a great service for the people of his state and of other states and to the Nation, and that he was entitled to great credit for his efforts.

Reduce Anthracite Freight Rates, Say the Experts

John Hays Hammond, chairman of the United States Coal Commission, referring to the recently published letter from Governor Pinchot of Pennsylvania, suggesting a means whereby the public need not shoulder the $32,250,000 increase in the production cost of coal necessitated by the 10-per cent wage increase, and that from President Lewis of the Miners' Union, in which the latter, in addressing President Coolidge, approved the suggestion of the former that excessive anthracite freight rates were reflected in the price of coal and that steps should be taken to force reduction to prevent an increase in coal prices to meet the increase in wages recently authorized in the Pinchot settlement, said today:

The Coal Commission in its anthracite report issued July 9 to the President and to the Congress recommended that the Interstate Commerce Commission institute an inquiry on anthracite coal freight rates. The Interstate Commerce Commission on the next day, in response to the recommendation of the Coal Commission, ordered an investigation of this question and on Aug. 31 fixed Sept. 24 as the date on which the hearings would begin.

The reasonableness of existing rates will thus be ascertained, as provided by law, but until the Interstate Commerce Commission renders its decision the public will not know whether or not there is ground to expect any relief from this source. The hearing will elucidate all the facts, and the adjustment, if warranted, will proceed in an orderly way.

Society Affairs

The Boston Plant Engineer's Club will hold its annual business meeting, including the election of officers, at a dinner to be given at the Boston City Club on Sept. 19, at 6:30 p.m.

The New England Water Works Association will have the following papers on its program that will be of interest to *Power* readers: "The Selection of Pumping Equipment from the Standpoint of Station Economy," by Frank A. Mazzur; "Some Applications of the Venturi Principle," by Frederick N. Connet; "Eliminating Water Hammer from a High-Pressure Regulating Valve and Experiences with Universal Pipe on Curves," by Sydney Lee Ruggles; "Testing, Maintenance and Operation of Large Gate Valves," by

Payne Dean; "Records of Stream Flow; Their Use and the Best Methods for Obtaining Them for Municipal and Industrial Purposes," by C. C. Covert; "Some Recent Developments in Steel Pipe," by H. T. Miller.

Business Notes

Joseph H. Spurgeon has recently opened a sales agency for power and heating equipment at 818 Woodmere Ave., Detroit, Mich., covering eastern Michigan and Northern Ohio territory.

The **Edward Valve & Manufacturing Co.**, East Chicago, Ill., announces that Olaf E. Oleson has resigned as president of the company and that W. W. Crawford has been elected to fill the vacancy.

The **Sarco Company, Inc.**, of New York City, has just appointed R. C. Doerr, late sales representative of the National Meter Co., as its engineering sales representative for northern New Jersey.

The **Homestead Valve & Manufacturing Co.**, manufacturer of the Homestead quarter-turn valve, announces that it has effected a consolidation with the Protective Seat Valve Co., Peoples Bank Bldg., Pittsburgh, Pa.

The American Schaeffer & Budenberg Corp., is the new firm name given to the consolidation, which was consummated about a year ago, of the American Steam Gauge & Valve Co., and the Schaeffer & Budenberg Mfg. Co.

The **Standard Turbine Corp.**, Wellsville, N. Y., announces the following changes in its organization: E. D. Spicer, formerly manager of the Kerr Turbine Co., becomes general manager of the corporation; H. H. Geiger has been appointed New York City manager, with offices at 350 Madison Ave.; Percy E. Wright, will act as its Seattle agent, with offices at 2012 L. C. Smith Bldg., Seattle, Wash.

Trade Catalogs

Lubricants—Dearborn Chemical Co., 1029 W. 35th St., Chicago, Ill. Catalog "Lubrication from Tallow to Dearborn Oil," gives advice on lubricants and the testing of them as well as a chart of recommendations.

CO_2 Recorder—Jos. W. Hays Corporation, Michigan City, Ind. Leaflet showing the operation and construction of this automatic CO_2 and draft recorder. Colored diagrams add to the attractiveness and assist in the explanation of the mechanism.

Tools, Portable Electric—Hisey-Wolf Machine Co., Cincinnati, Ohio. **Miniature catalog** No. 3027, gives a brief description of these tools, which are used around the power plant. Illustrations and tables of types, volts, speeds, weights, etc., add to its usefulness.

Pumps, Centrifugal—Alberger Pump and Condenser Co., 140 Cedar St., New York City. Catalog G shows by means of photos and text the working and construction of centrifugal pumps and the Alberger-Curtis steam turbines. Tables, of useful information, include friction, pressures and dimensions.

Cranes—Industrial Works, Bay City, Mich. Book 115 is a Fiftieth Anniversary edition and is worthy of the event. It is a book that any publisher would be proud to put his name on. It contains colored illustrations, that might well be taken out and framed—which not only tell the story of the crane, and its uses, but have great artistic merit. The drawings that illustrate the foreword are in keeping with the colored pictures and show, as the foreword states that they are fifty years young. Pictures of the installations of the cranes, not only feature the cranes but the country in which they operate. A fine index, useful tables and explanatory drawings are all included but so well is the book put together that one wonders if one is not looking over some volume describing countries where skies are always golden.

Coming Conventions

American Electric Railway Engineering Association. James W. Welsh, 8 West 40th St., New York City. Annual Convention at Young's Pier, Atlantic City, Oct. 8-12.

The American Electrochemical Society. Colin G. Fink, Columbia University, New York City. Convention at Dayton, Ohio, Sept. 27-29.

American Institute of Electrical Engineers, F. L. Hutchinson, 29 West 39th St., New York City. Pacific Coast Convention at Del Monte, Calif., Oct. 2-5.

American Society of Mechanical Engineers, Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 3-6.

American Society of Refrigerating Engineers, William H. Ross, 35 Warren St., New York City. Nineteenth Annual Convention at New York City, Dec. 3-5.

American Welding Society. M. M. Kelly, 33 West 39th St., New York City. Fall Meeting, Pittsburgh, Pa., Oct. 24-26.

Association of Iron & Steel Electrical Engineers; J. F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Iron and Steel Exposition at Buffalo, N. Y., Sept. 24-28.

Association of Railway Electrical Engineers. Jos. A. Andreuccetti, Room 413, Chicago & Northwestern R.R. Station, Chicago, Ill. Thirteenth Annual Convention at Hotel La Salle, Chicago, Ill., Nov. 6-9.

Electric Power Club. S. N. Clarkson, 900 B. F. Keith Bldg., Cleveland. Fall meeting at French Lick Springs Hotel, French Lick, Ind. Nov. 19-22.

Empire State Gas & Electric Association, Charles H. B. Chapin, Grand Central Terminal Bldg., New York City. Meeting at Lake Placid, N. Y., Oct. 8-9.

Illuminating Engineering Society, H. E. Mahan, Schenectady, N. Y. Convention at Fort William Henry Hotel, Lake George, N. Y., Sept. 24-28.

Indiana Electric Light Association, T. Donahue, Northern Indiana Gas & Electric Co., Lafayette, Ind. Meeting at French Lick Springs, Ind., Sept. 26-29.

National Association of Practical Refrigerating Engineers; Ed. H. Fox, 5707 W. Lake St., Chicago. Fourteenth Annual Convention at Memphis, Dec. 12-16.

National Exposition of Power and Mechanical Engineering; Charles F. Roth, Room 1102, Grand Central Palace, New York City. Power Show, Dec. 3-8.

National Safety Council, W. H. Cameron, 168 North Michigan Ave., Chicago, Ill. Twelfth annual congress at the New Statler Hotel, Buffalo, N. Y., Oct. 1-5.

New England Association of Commercial Engineers; James F. Morgan, 53 Devonshire St., Boston, Mass. Power Show at Mechanics Bldg., Boston, Mass., Oct. 29-Nov. 3.

New England Water Works Association; Frank J. Gifford, 715 Tremont Temple, Boston, Mass. Annual Convention at Burlington, Vermont, Sept. 18-21.

Society of Naval Architects and Marine Engineers, Daniel H. Cox, 29 West 39th St., New York City. Annual meeting at New York City, Nov. 8-9.

West Virginia-Kentucky Association of Mine, Mechanical and Electrical Engineers; Herbert Smith, Room 211, Robson-Prichard Bldg., Huntington, W. Va. Third annual convention at Frederick Hotel, Huntington, W. Va., Oct. 19-20.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Sept., 1923	Sept. 10, 1923
Pool 1,	New York	$3.00@3.50	$3.00@3.50
Smokeless,	Columbus	2.75@3.25	2.75@3.25
Clearfield,	Boston	1.90@2.50	1.85@2.50
Somerset,	Boston	2.25@2.75	2.25@2.75
Kanawha,	Columbus	1.75@2.10	1.75@2.10
Hocking,	Columbus	1.75@2.00	1.85@2.00
Pittsburgh No. 8	Cleveland	2.10@2.15	2.05@2.15
Franklin, Ill.	Chicago	2.75@3.25	2.75@3.25
Central, Ill.	Chicago	2.10@2.35	2.10@2.35
Ind. 4th Vein,	Chicago	2.50@2.75	2.50@2.75
West Ky.,	Louisville	1.85@2.00	1.85@2.10
S. E. Ky.,	Louisville	1.75@2.25	1.75@2.25
Big Seam,	Birmingham	1.75@2.15	1.75@2.15

FUEL OIL

New York—Sept. 13, light oil, tank car lots, 28@34 deg. Baumé, 3¾c. per gal., 36@40 deg. 4c. per gal., f.o.b. Bayonne, N. J.

Chicago — Aug. 15, 24@26 deg. Baumé, $1.81½@1.86½ per bbl.; 32@36 deg., $2.01½@2.6½ per bbl., tanks cars.

St. Louis—Sept. 4, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.85 per bbl.; 26@28 deg., $1.90; 28@30 deg., $2.00; 32@36 deg., gas oil, $2.25; 36@40 deg., distillate, $2.40@2.45.

Pittsburgh—Sept. 4, f.o.b. local refinery, 30@34 deg., fuel oil, 4¼c. per gal.; 36@40 deg., fuel oil, 5¼c.; 34 deg., neutral 7c.

Dallas—Sept. 8, f.o.b. local refinery, 26@30 deg., $1.35 per bbl.

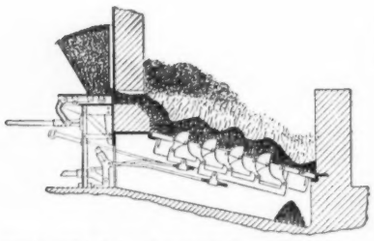
Cincinnati — Sept. 4, tank-car lots f.o.b. local refinery, 26@30 deg. Baumé, 4¼c. per gal.; 30@32 deg., 4¼c.; 38@42 deg., distillate, 5¾c.

Philadelphia—Aug. 29, 26@28 deg., $2@2.10 per bbl.; 16@20 deg., $1.78@1.85; 14@16 deg., $1.60@1.66½.

Condensed-Clipping Index of Equipment

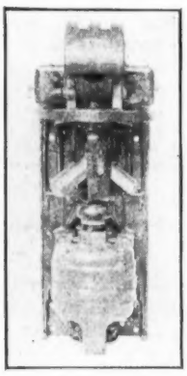
Condensed from previous descriptions in "Power" for convenient filing

Stoker, Marion, Hand "Power," 1923.
Marion Machine Foundry & Supply Co., Marion, Ind.



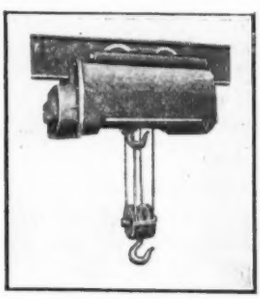
Type "C" Hand Stoker is hopper fed, with levers operating a feeding plunger and an alternating set of bars so that the coal is moved forward on the grates, breaking up the bed and permitting a circuation of air through the burning coal. The iron used in the frame and rods has a high heat resistance. The stoker is fitted with a small ash dump at the rear of the grate which is operated by a lever from the front of the furnace.

Centrifugal Closing Device for Oil Circuit Breaker, Motor Operated "Power," 1923.
General Electric Co., Schenectady, N. Y.



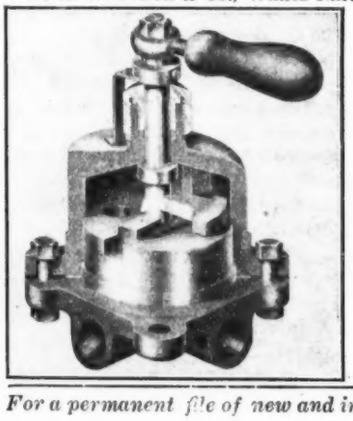
A motor-driven centrifugal mechanism for closing oil circuit breakers was primarily designed for application in connection with the remote control of circuit breakers on alternating-current lines up to and including 800 amps., at 15,000 volts, it has also been found adaptable to use on the automatic reclosing equipments recently developed by the company. It can be used on direct-current circuits by substituting a direct-current motor. The motor, when its circuit has been closed by a control relay rapidly rotates a pair of weights, the centrifugal force of which closes the breaker through a mechanism. When the control relay is actuated by a push button, or other circuit-closing device, it closes the motor circuit and holds it closed until the breaker closes the motor circuit, even if the actuating device is opened. When the breaker is closed the closing current is broken by an auxiliary switch mounted on the breaker mechanism.

Hoist, "Lo-Hed" Mono-Rail, Electric "Power," 1923.
American Engineering Co., Philadelphia, Pa.



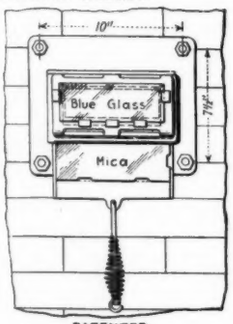
This hoist, "Lo-Hed," is enclosed and has a low overhead of 10 in. for 1 ton and 14 in. for 3 ton hoist. It is useful for rooms where the ceilings are low and where ice blocks or articles of large dimensions are handled. All shafts are of high carbon steel, with roller-bearing races pressed on the ends; roller bearings are of the Hyatt, high-duty type; gears are straight spur of forged steel, machine cut teeth for the hoisting drive; pinions are of high-carbon steel, heat treated. When the load block has reached its upper limit of travel an automatic device breaks the electric circuit and applies the holding brake. The motor can be removed in 10 minutes without disturbing the other hoist parts and with a full load on the hoist hook if necessary.

Valve, Air or Steam "Power," 1923.
W. H. Nicholson & Co., Wilkes-Barre, Pa.



This controlling valve for air or steam is used where one, two or three ports are needed. The areas of the ports are the same as for the supply pipes. This valve is especially fitted for operating the clutch of an electric hoist, or the air cylinder for lifting a furnace door as well as for other application.

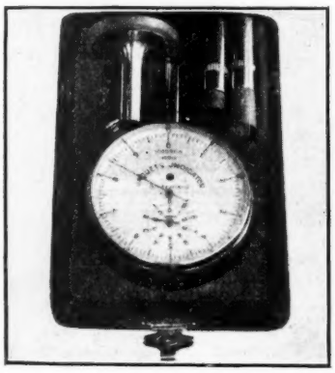
Furnace Window "Power," 1923.
J-B Products Co., Hartford, Conn.



PATENTED
Opening in frame 3½"x 7½"
Opening in wall should be made 2½"x 6½"

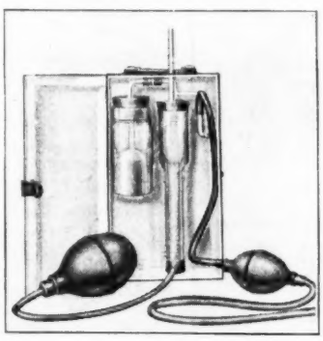
The C-E-Z furnace window, adapted for use on furnaces of all types, consists of a window frame containing a stationary blue glass with an air space between the blue glass and the furnace. As a protection for the blue glass there is a board of asbestos arranged as a slide in which is mounted a piece of mica. When it is necessary to see the inside of the furnace, the slide is adjusted so that the mica comes in front of the opening in the furnace and the fire is readily viewed through the blue glass without injury to the eyes and without the inrushing of cold air across the boiler tubes or shell.

Tachoscope, O-Z Direct-Reading "Power," 1923.
O. Zernickow, 15 Park Row, New York City.



This instrument is anti-magnetic, with a time unit of 6 seconds for r.p.m., or using the disk wheel supplied, feet per minute, and is designed to register up to 30,000 r.p.m. The size of the carrying case is 4¾ x 3 x 1¾ in. and weighs 10 oz. The weight of the instrument without the case is 6 oz. and the diameter of the dial 2 inches. The lever with button winds the watch mechanism and it is designed to zero the counting mechanism from previous readings.

Analyzer, Republic Flue Gas "Power," 1923.
Republic Flow Meters Co., 2240 Diversey Parkway, Chicago, Ill.



This small size CO_2 testing apparatus is compactly arranged in a steel case and is adapted to analyzing samples under all conditions. On account of its small size, as compared with the ordinary Orsat, it is particularly well adapted to every-day boiler room use where the instrument must be frequently carried from one point to another.

Conveyor, Maroa Portable Belt "Power," 1923.
Maroa Manufacturing Company, Maroa, Ill.

A portable belt conveyor mounted on wheels with a supporting structure on which the driving motor or gasoline engine can be placed is being made for a variety of uses by this company. The belt which runs over pulleys at either end is supported by a traveling track consisting of a link belt chain at either side with cross pieces at intervals. The track moves at the same speed as the dependent take-up devices. The conveyor is made for the following three widths of belt: 10, 12, and 16 in., in three lengths of 20, 25 and 30 ft. for each size, with capacities of 25, 40 and 90 tons per hour respectively.

For a permanent file of new and improved power-plant equipment, clip and paste on 3 x 5-in. cards. (Patented Aug. 20, 1918.)

New Plant Construction

PROPOSED WORK

Ark., Blytheville—L. L. Vandervoort, Paragould, is having preliminary plans prepared for the construction of an 8 to 10 story store and hotel building, here. Estimated cost $250,000. Private plans.

Ark., Fort Smith—The Border City Ice & Cold Storage Co., 1st and E Sts., A. Williams, Ch. Engr., is in the market for a 500 hp. steam boiler for plant.

Calif., Long Beach — The Long Beach Press, 123 East Broadway, is having plans prepared for the construction of a 12 story, 75 x 150 ft. newspaper and office building. Estimated cost $1,000,000. W. H. Austin, 1st Natl. Bank Bldg., Long Beach, Archt. Equipment detail not reported.

Calif., Long Beach—The Security Trust & Savings Bank, 1st and Pine Sts., is having plans prepared for the construction of a 12 story, 75 x 150 ft. bank and office building. Estimated cost $1,000,000. Curlett & Beelman, Union Bank Bldg., Los Angeles, Archts. Equipment detail not reported.

Calif., Los Angeles—G. E. Barrett, 931 Bartlett Bldg., plans to build a 12 story, 125 x 175 ft. apartment house on 6th and Rampart Sts.

Calif., Macdoel — The trustees of Butte Valley Irrigation Dist. will receive bids until Sept. 24 for the construction of 21 miles canals, 22 miles laterals, 6 miles drains, 120 turnouts, 35 checks, 30 culverts, 30 farm bridges, pipe and two 30 in. centrifugal horizontal split case pump units driven by electric motors. C. T. Darley, Klamath Falls, Ore., Engr. Noted Sept. 5, 1922.

Calif., Red Bluff—The city, E. F. Lennon, Clk., will receive bids until Sept. 24 for extensions to waterworks system, including one 2 hp. automatic pump.

D. C., Wash.—The Washington City Central Trust Co., Metropolitan Bank Bldg., is having plans prepared for the construction of a bank and office building on 15th St. and New York Ave. Estimated cost $1,500,000. Coolidge & Shattuck, Ames Bldg., Boston, Mass., Archts.

Fla., Fort Lauderdale—The Tarpon Bend Hotel Co., c/o W. S. Pratt, Miami, is having plans prepared for the construction of a 10 story, 60 x 300 ft. hotel on Tarpon Bend, here. Estimated cost $360,000. A. J. O'Reilly, Lemon City, Engr. Pfieffer & O'Reilly, Lemon City, Archts. Otis elevators will be installed.

Fla., Orlando—The city defeated $525,000 bonds for extensions and improvements to waterworks and electric light plant. Noted Aug. 28.

Fla., Tampa—The city plans to expend $1,273,000 for waterworks. N. S. Hill, 112 East 19th St., New York, Engr.

Ill., Chicago—Silverman & Kerman, c/o Dubin & Eisenberg, Archts., 14 West Washington St., are having plans prepared for the construction of a 3 story, 298 x 307 ft. apartment house, including steam heating system, on Woodlawn Ave. near Hyde Park Blvd. Estimated cost $750,000.

Ill., Shelbyville—The city is having plans prepared for a waterworks system, including pipe, fire hydrants, 150,000 gal. tank, tower, two motor driven pumps, etc. W. A. Fuller Co., 1917 Railway Exchange Bldg., St. Louis, Mo.

Ind., Columbia City—The city is in the market for equipment, including boilers, stokers, superheaters, etc., for addition to power and waterworks plant. C. Brossman, 1503 Merchants' Bank Bldg., Indianapolis, Consult. Engr.

Kan., Kansas City—The city will hold an election Oct. 23 to vote $2,000,000 bonds for improvements to electric light plant. R. L. McAlpine, Engr. Noted Sept. 4.

Kan., Wichita—The B. P. O. E., c/o H. G. Boyd, 10 Elks Lodge, and E. Forsblom, 305 Sedgwick Bldg., will receive bids until Oct. 8 for the construction of a 6 story, 140 x 150 ft. club building on North Market St. Estimated cost $500,000. H. G. Noble, Reliance Bldg., Kansas City, Mo., Engr. Equipment detail not reported.

Kan., Winfield—The city, c/o J. Welfelt, City Mgr., voted $112,000 bonds and is having preliminary surveys made for water mains, pumps, motors, etc. H. P. Haynes, Winfield, Engr.

Ky., Ashland — The Buckingham Hotel Co. will soon receive bids for the construction of a 9 story, 143 x 200 ft. hotel. Estimated cost $1,325,000. J. R. Gieske, Foster Bldg., Huntington, W. Va., Archt. Equipment detail not reported.

Ky., Louisville — The Ford Motor Co., Highland Park (Detroit P. O.), plans to build an assembly plant, capacity 300 cars per day, on a 22 acres site on Western Parkway, here. Estimated cost $1,000,000.

Ky., Louisville—The Kosairs Assn. Bldg. Com. received bids for the general contract for the construction of a 7 story temple, hotel, etc., on Broadway from C. A. Koerner & Co., 318 East Burnett St., Louisville. Estimated cost $1,350,000. Equipment detail not reported. Noted June 19.

Ky., Louisville — Nevin, Wischmeyer & Morgan, Archts., Starks Bldg., will receive bids until Oct. 20 for the construction of a temple on 4th and Breckenridge Sts. for the Scottish Rite Assn., 438 6th St. Estimated cost $750,000. Equipment detail not reported.

Mich., Dearborn — A. Kahn, Archt., 1000 Marquette Bldg., Detroit, is receiving bids and will open same about Sept. 20 for the construction of a 1 story, 56 x 140 ft. addition to power house on Oakwood Blvd., here, also connecting tunnel, 9 ft. diameter, 300 ft. long, for the Ford Motor Co., Highland Park (Detroit P. O.). Mechanical equipment has been purchased by owner.

Mich., Detroit — Kohner & Seler, Archts., 405 Kresge Bldg., are preparing plans for the construction of a 4 story, 140 x 200 ft. apartment and store building on North Woodward St. Estimated cost $500,000. Owner's name withheld. Steam heating boilers and accessories will be installed.

Mich., Detroit—Varney & Varney, Archts., 1422 Washington Blvd., are preparing plans for the construction of an 8 story, 85 x 150 ft. hotel, including steam heating equipment and three elevators, on Alexandrine Ave., W. Estimated cost $400,000. Owner's name withheld.

Mich., Detroit — B. C. Wetzel & Co., Archts., 2317 Dime Bank Bldg., are preparing plans for the construction of a 12 story, 60 x 150 ft. bank and office building, including steam heating system. Estimated cost $700,000. Owner's name withheld.

Minn., Duluth—C. Schroeder & Sons, 86 Michigan St., Milwaukee, Wis., will receive bids until Sept. 28 for the construction of an 8 story, 165 x 180 ft. hotel, including steam heating system, on Linden Rd. and 12th Ave., here. Estimated cost $1,000,000. M. Tullgren & Sons Co., 425 East Water St., Milwaukee, Wis., Engrs. and Archts.

Minn., East Grand Forks—The Minnesota Sugar Co., 811 Metropolitan Bank Bldg., Minneapolis, H. A. Douglas, Pres., plans to build a beet sugar factory, here. Estimated cost $1,500,000. Engineer or architect not selected.

Miss., Hollandale—The city, G. Hamilton, Clk., rejected bids for the construction of a sewer system, including vitrified pipe, manholes, three flush tanks, pump house, centrifugal pump and electric motor. The project has been postponed until spring. Bobo & Collier, Clarksdale, Engrs.

Miss., Jackson—The Lamar Life Insurance Co. will receive bids until Sept. 17 for the construction of a 10 story office building. Estimated cost $500,000. Sanguinette, Staats & Hedrick, 1st Natl. Bank, Fort Worth, Tex., Archts. Equipment detail not reported. Noted June 26.

Mo., Miller — The city is having plans prepared and will soon receive bids for an electric light and waterworks plant, distribution mains, etc. Estimated cost $25,000. Alexander Eng. Co., Springfield, Engrs.

Mo., St. Louis—The Electric Storage Battery Co. of Phila., Federal Reserve Bank Bldg., is having preliminary plans prepared for the construction of a 2 and 3 story factory building, to contain 30,000 sq.ft. of floor space, the first of a group of three similar buildings on Vandeventer St. Estimated cost $200,000. Kleipstein & Rathmann, Chemical Bldg., St. Louis, Archts.

N. J., Trenton—The City Comn., L. D. Hirsch, Clk., will receive bids until Sept. 21 for a 15 hp., 230 volt, 1,150 r.p.m. compound wound motor; 6 in. type, bronze fitted, single stage, double suction, split casing centrifugal pump. A. Bugbee, City Hall, Engr.

N. J., Trenton — The Whitehead Bros. Rubber Co., Whitehead Rd., plans to build a boiler house, estimated cost $10,000, and to install three 100 hp. boilers.

N. J., Wallington (Rutherford P. O.)—The Passaic Valley Sewerage Comrs., J. H. Quigg, Clk., 900 Chamber of Commerce Bldg., Newark, will receive bids until Oct. 2 for furnishing and erecting pumping machinery and equipment for pumping station, here.

N. Y., Brooklyn—J. Horowitz, c/o W. T. McCarthy, Engr. and Archt., 159 Remsen St., is having plans prepared for the construction of a 10 story apartment house on Eastern Parkway. Estimated cost $1,000,000. Equipment detail not reported.

N. Y., Brooklyn — S. L. Malkind, Engr. and Archt., 16 Court St., is preparing plans for the construction of an apartment house on Bath Ave. Estimated cost $1,000,000. Owner's name withheld. Equipment detail not reported.

N. Y., Buffalo — The Comr. of Public Wks., Municipal Bldg., will receive bids until Oct. 23rd for furnishing and installing centrifugal pumps and motors, also switchboard and apparatus for the low lift pumping station in connection with the filter plant. G. C. Andrews, Engr.

N. Y., Buffalo—The State Hospital Comn., Capitol, Albany, will receive bids until Sept. 19 for refrigeration, electric elevators, etc., for the State Hospital, here. S. W. Jones, Capitol, Albany, Archt.

N. Y., Buffalo—The Supt. of Lighthouses will receive bids until Sept. 24 for oil engine driven electric generator unit and electric motor driven air compressor unit, etc.

N. Y., New York—The Dept. of Public Welfare, Municipal Bldg., received bids for addition to refrigerator plant, also additions and alterations to refrigerators at the City Home, Welfare Island, from the Norwalk Refrigerating & Equipment Co., Inc., 35 Warren St., $13,721; L. C. Smith, $14,250. Noted Sept. 4.

N. Y., New York—W. H. Gompert, Archt., Bd. Educ., Flatbush Ave. Extension and Concord St., Brooklyn, will receive bids until Sept. 25 for the construction of James Monroe High School on Boynton Ave. and 172nd St., here. Noted Sept. 4.

N. Y., North Tonawanda—The Ontario Paper Co., Thorold, Ont., W. Curtis, Genl. Mgr., plans to build a pulp mill on Little Island, here. Estimated cost $3,000,000. The owner is in the market for complete machinery for the manufacture of paper from wood pulp.

N. Y., Oneida—The Madison House Hotel Corp., 136 Madison St., J. H. Cassidy, 111 West Kennedy St., Syracuse, interested, plans to build a 5 story hotel and theater building, here. Estimated cost $250,000.

N. C., Asheville—E. W. Grove, St. Louis, Mo., is receiving bids for the construction of a 90 x 100 ft. hotel, here. Estimated cost $600,000. J. M. Geary, Asheville, Archt. Equipment detail not reported.

N. C., Lexington—C. M. Wall & Sons are in the market for a 375 hp. Corliss engine or equal.

Ohio, California—E. P. Durr, Acting Dir. of Public Service, City Hall, Cincinnati, will receive bids until Sept. 20 for the construction and erection of electric coal hoisting machinery for the river pumping station, here.

Ohio, Cincinnati—The Bethesda Hospital, Lafayette and Middletown Aves., is having plans prepared for the construction of a hospital. Estimated cost $600,000. S. Hanneford & Sons, 1024 Dixie Terminal Bldg., Cincinnati, Archts. Equipment detail not reported.

Ohio, Cleveland—The Marmon Improvement Co., c/o M. Marmorstein, Pres., Ulmer Bldg., is having preliminary plans prepared for the construction of a 10 story hotel, including steam heating system, at 2300 Euclid Ave. Estimated cost $1,500,000. W. S. Ferguson Co., 1900 Euclid Ave., Cleveland, Archts.

Ohio, Toledo—The Maumee Hotel Co. is having plans prepared for the construction of a 12 story, 60 x 120 ft. hotel on St. Clair and Jefferson Sts. Estimated cost $1,500,000. A. Hahn, Toledo, Engr. Equipment detail not reported.

Okla., Cyril—The city, M. M. Rowe, Clk., voted $31,000 bonds and is having plans prepared for waterworks system, including well, deep well pump, 10 hp. engine, tank, tower and distribution system. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City, Engrs. Noted Dec. 19, 1922.

Okla., Oklahoma City—The Doctors & Dentists Bldg. Co. is having plans prepared for the construction of a 13 story bank and

office building on 1st St. and Broadway. Estimated cost $1,000,000. Layton, Smith & Forsythe, 701 South West Natl. Bank Bldg., Archts. Equipment detail not reported.

Okla., Oklahoma City—The Laird-Arms Co., c/o Bailey & Alden, Archts., Colcord Bldg., is having plans prepared for the construction of a 12 story, 162 x 200 ft. apartment house, including steam heating and refrigerating systems, on 10th St. Estimated cost $1,400,000.

Ore., Portland — The Port of Portland, J. H. Polhemus, Genl. Mgr., Spaulding Bldg., is having plans prepared for a dredge equipped with four 750 hp. Diesel engines and 30 in. suction and discharge pipe. G. B. Hegardt, Stark St. Dock, Portland, Engr.

Pa., Phila. — H. J. Homan Co., 1713 Chestnut St., contractor, C. Fleming, Purch. Agt., is in the market for refrigerating machinery, oil burning boilers, flanged valves, piping, 4 in. water meter, pumps, elevators, etc.

Pa., Phila.—The Phila., Q. M., Intermediate Depot, 21st St. and Oregon Ave., will receive bids until Sept. 26 for replacing present coal burning equipment with oil burning equipment under three boilers in central heating plant.

Pa., Phila.—The Vice President of the Amer. Ice Co., 121 North Broad St., will receive bids until Sept. 21 for the construction of a 3 story, 57 x 150 ft. addition to ice manufacturing and storage plant on 17th and Washington Sts. Estimated cost $80,000. C. L. Weir, 41 East 42nd St., New York, Archt.

Tenn., Knoxville—The University of Tennessee plans to build a 60 x 70 ft. heating and power plant with two 350 hp. boilers.

Tex., Dallas—The Republic Natl. Bank plans to build an 18 story, 97 x 100 ft. bank and office building on Main and Exchange Sts. Estimated cost $500,000. Engineer or architect not announced.

Tex., Desdemona—The Desdemona Electric Co. is in the market for a 25 hp. oil engine a.c., electrical unit and switchboard.

Tex., Edgewood—The city will soon receive bids for waterworks improvements, including two crude oil engines direct connected to alternators; motor driven centrifugal pump; c.i. pipe; steel tank and tower; hydrants and valves. Estimated cost $40,000. Municipal Eng. Co., 715 Praetorian Bldg., Engrs. Noted Aug. 28.

Tex., Fort Worth — The city plans to build a city hall and auditorium on Throckmorton St. Cost will exceed $500,000. Engineer or architect not announced.

Tex., Galveston—A syndicate is having plans prepared for the construction of a 10 story, 110 x 160 ft. hotel. Estimated cost $1,000,000. P. G. Silber & Co., 331 Bedell Bldg., San Antonio, Archts. Equipment detail not reported.

Tex., San Antonio — The Subscription & Loan has had plans prepared and will receive bids about Sept. 25 for the construction of a 12 story medical arts building on Houston St. and Ave. E. Estimated cost $900,000. M. E. Simpson Co., 4th Natl. Bank Bldg., San Antonio, Engrs. R. H. Cameron, 1115 City Natl. Bank Bldg., San Antonio, Archt. Separate bids will be received for heating and ventilating apparatus. Noted May 15.

Va., City Point—Wilson Hock is in the market for a 150 hp., 16 x 36 in. Corliss steam engine.

Va., Danville—The city, F. Talbott, Supt. Water Dept., will receive bids until Oct. 11 for waterworks improvements, including (1) construction of a coagulating basin, aerator and reconstruction of filters; (2) high and low lift centrifugal pumping machinery, etc.

Wis., Appleton—The City Water Comm., c/o F. Morris, Secy., is receiving bids for two generators.

Wis., Athens—The village, C. F. Hamilton, Clk., is having plans prepared for water and sewage systems, including water supply, pumping equipment, mains and sewage disposal plant. Estimated cost $77,000. W. G. Kirchopper, Dean Bldg., Madison, Engr. Noted Aug. 7.

Wis., Madison—Balch & Lippert, Archts., Gay Bldg., are receiving bids for the construction of a 10 story, 44 x 120 ft. hotel, including steam heating system, on Pinckney St. for the Piper Bros. Co., 31 North Pinckney St., S. A. Piper, Pres. Estimated cost $300,000.

Wis., Madison—P. M. Homer, Engr., Pioneer Bldg., will soon receive bids for a steam heating plant, including boilers, piping and radiation for H. C. Schenk, 205 Atwood Ave.

Wis., Madison—Piper Bros. Co., c/o S. Piper, 31 North Pinckney St., is in the market for refrigeration equipment, ice machine, etc., for proposed $1,000,000 hotel.

Wis., Wisconsin Rapids—The Nekoosa-Edwards Paper Co., Port Edwards, is having plans prepared for addition to its hydro-electric plant, here, to increase capacity from 2,800 to 5,800 hp., including installation of turbines (waterwheels), auxiliary boilers, etc. E. P. Gleason, c/o owner, Engr.

Wis., Waukesha — M. Tullgren & Sons Co., Archts., 425 East Water St., Milwaukee, have prepared plans and will soon receive bids for the construction of a 3 story hotel for F. J. Strong, 151 South East Ave., here. Estimated cost $400,000. Equipment detail not reported.

Ont., Fonthill—The town is having plans prepared for a waterworks system, including c.i. mains, reservoir, electric and gasoline 3 stage centrifugal pumps, pumphouse, valves and hydrants. Estimated cost $52,000. James, Proctor & Redfern, 36 Toronto St., Toronto, Engrs.

Ont., Meaford—The Hydro-Electric Power Comn. of Ontario, 110 University Ave., Toronto, is having plans prepared for the installation of power plant to supply Meaford and towns in vicinity with electric power. Estimated cost $500,000. F. A. Gaby, Ch. Engr. Noted Feb. 27.

Ont., Paris—The town, C. B. Barker, Clk., voted $25,000 for extension of municipal hydro-electric system, light and power lines. The work will be done by day labor.

Ont., Timmins—The Hollinger Consolidated Gold Mines will receive bids about Sept. 22 for the construction of buildings, later for equipment, including switchboards, meters, step down and series transformers, oil switches and lightning arresters; also for the construction of an 80 mile, 88,000 or 110,000 volt transmission line from here to power house at Island Portage, Abitibi River, steel towers, insulators, poles, telephone and power cable. Separate bids will be received on the latter for materials and construction. Estimated cost $1,000,000. Kerry & Chace, Ltd., 550 Confederation Life Bldg., Toronto, Engrs.

Ont., Toronto—The city, C. A. Maguire, Mayor, will receive bids until Oct. 9 for one 80,000,000 gal. centrifugal pump, 25,000,000 gal. pumping engine, a.c. generator, c.i. pipe, stop valves and special castings. R. C. Harris, City Hall, Engr.

Que., Pierrevil'e—The Dept. of Public Wks., R. C. Desrochers, Secy., will receive bids until Sept. 21 for supplying and installing hot water system of heating for post office building, here.

Sask., Melville—The town is in the market for equipment for electric light and power plant.

CONTRACTS AWARDED

Ark., McGehee—The city awarded the contract for sewers, pumping stations and disposal works in Sanitary Dist. 1 to the Merkle Mchy. Co., 1733 Walnut St. Kansas City, Mo., $85,306. Noted Aug. 14.

Ark., Piggott—The city awarded the contract for sewers to the Merkle Mchy. Co., 1733 Walnut St., Kansas City, Mo., $38,475; 100 hp. and 75 hp. oil burning engines to Fairbanks, Morse & Co., 1218 Liberty St., Kansas City, Mo., $20,629; construction of power plant to E. E. Porterfield and E. C. Johnson, Piggott, $5,235. Noted Feb. 27.

Calif., Los Angeles—F. A. Powell, et al., c/o contractors, awarded the contract for the construction of a 10 story apartment house on Hollywood Blvd. to the Richardson Bldg. & Eng. Co., 141 North Larchmont Blvd., Los Angeles. Cost will exceed $750,000. Equipment detail not reported.

Calif., Monterey—R. Jacks, c/o O'Brien Bros., Inc., 315 Montgomery St., San Francisco, awarded the contract for the construction of a hotel, here, to F. L. Hansen, 251 Kearney St., San Francisco. Estimated cost $500,000. Equipment detail not reported. Noted July 17.

Calif., Oakland—J. R. Kaelin, 1933 5th Ave., awarded the contract for the construction of a 1 story boiler house, garage and laundry on 23rd Ave. and Boehmer St. to H. J. Christiansen, 505 17th St., Oakland, $56,125.

Calif., San Diego—St. Joseph's Hospital awarded the contract for the construction of a 7 story hospital to the W. E. Kier Constr. Co., 1st Natl. Bank Bldg., San Diego, $564,000. Ultimately it is planned to add 125 ft. wings at an additional cost of $400,000. Equipment detail not reported. Noted July 10.

Ill., Kewanee — The city awarded the contract for one 300 kw. and one 500 kw. turbo generator to the Medwest Engine Co., Anderson, Ind., $36,376; miscellaneous machinery and street lighting system to the Merkle Mchy. & Contg. Co., 1733 Walnut St., Kansas City, Mo., $73,900. Noted Aug. 21.

Ill., Pittsfield—The city awarded the contract for waterworks improvements, including earth dam, gate chamber, conduit spillway, filter, pumping plants, etc., to Nixon & Keeley, Murphy Bldg., East St. Louis. Noted Aug. 21.

Ind., South Bend—The Tuttle Mfg. Co., 49 West Washington St., awarded the contract for the construction of a 10 story, 100 x 160 ft. store and office building to the Bedford Constr. Co., 810 Fletcher Savings & Trust Bldg., Indianapolis. Estimated cost $600,000. Steam heating system will be installed.

Ia., Cedar Rapids—The Bd. of County Supervisors, Marion, awarded the contract for the construction of a 3 story court house on Municipal Island to Madsen & Peterson, 646 Builders' Exch., Minneapolis, Minn., $503,328. Heating contract has not been awarded. J. W. Royer, Urbana, Ill., Archt. Noted Aug. 7.

Kan., Lyons—The city awarded the contract for a sewer system, including sewers and sewage treatment plant with Imhoff tank intermittent sand filter to C. H. Everett, Hutchison, $91,452.81. Contract for two 200 g.p.m. and two 100 g.p.m. ejectors has not been awarded. Noted Aug. 21.

Mich., Detroit—The City Water Bd. awarded the contract for furnishing and installing one 37,000,000 gal. vertical triple expansion crank and flywheel pumping engine to the Worthington Pump & Mchy. Co., 115 Broadway, New York, $247,000. Noted Sept. 4.

La., West Monroe—The city, E. F. Thompson, Secy., awarded the contract for the construction of sewer system and pumping station to the McIntosh Co., New Orleans. Estimated cost $90,000. Noted July 31.

Mich., Detroit—The Bollin McKinney Hotel Co., c/o L. Kamper, Archt., Kamper Bldg., awarded the contract for the construction of an 8 story, 86 x 145 ft. hotel, including steam heating system, on John R St. to the Lynch Constr. Co., 1200 Washington Blvd., Detroit. Estimated cost $800,000. Noted May 1.

Mich., Detroit — The Public Lighting Comn., East Atwater St., awarded the contract for furnishing and installing eight boilers and eight superheaters for power plant to the Babcock & Wilcox Boiler Co., 411 Ford Bldg., Detroit, $399,416.

Mich., Detroit—The Texas Co., 17 Battery Pl., New York, awarded the contract for the construction of a bulk distribution plant, including a 1 story, 38 x 122 ft. warehouse and office building, a 32 x 100 ft. power plant and garage, steel tanks, etc., on Ferndale Ave., here, to the McKelvey Constr. Co., 426 Hammond Bldg., Detroit. Estimated cost $100,000.

Mo., Kansas City—The Kansas City Light & Power Co., 1330 Grand Ave., will build a power plant by day labor on 6th and Penn Sts. Estimated cost $60,000.

Mo., St. Louis—The Union Electric Light & Power Co., 12th and Locust Sts., awarded the contract for laying twelve cables carrying 12,000 kw. connecting power plant at Cahokia, Ill., with station, here, to the Fruin-Colnon Constr. Co., Merchants-Laclede Bldg., St. Louis. Estimated cost $156,000.

N. J., Atlantic City — F. B. Off, Hotel Brighton, awarded the contract for the construction of a hotel on Illinois Ave. to the H. Burton Co., 1713 Sansom St., Phila., Pa. Estimated cost $300,000. Equipment detail not reported. Noted Aug. 28.

N. Y., New York — The Lapidus Eng. Corp., 200 West 72nd St., will build a 14 story, 100 x 150 ft. hotel at 206 West 70th St. Estimated cost $2,000,000. Owner will do general work and let sub-contracts. G. F. Pelham, 200 West 72nd St., Engr. and Archt. Equipment detail not reported.

N. Y., Wende (Millgrove P. O.)—The county, Room 29, City Hall, Buffalo, awarded the contract for the construction of a county home and infirmary, here, to H. Schenk, Erie, Pa., $1,079,000; heating and ventilating apparatus to the Chippewa Co., 329 Delaware Ave., Buffalo, $71,500. Noted July 24.

Ohio, Cleveland—The city awarded the contract for economizers, forced and induced draft fans on municipal light plant to the B. F. Sturtevant Co., Swetland Bldg., Cleveland, $47,136.

Okla., Maysville—The city awarded the contract for pumping station, distribution system, tank, tower, valves, hydrants and deep well pump to Gibson & Mitchell, Pauls Valley, $33,833.50. Noted May 8.

Tex., Corsicana — The Navarre Ice Co. awarded the contract for the construction of a 1 story, 90 x 150 ft. ice plant on 12th St. to Carson & Gallahar, Corsicana. Estimated cost $100,000. Noted Aug. 21.

Tex., Dallas—The Terminal Bldg. Corp., S. W. Life Bldg., awarded the contract for the construction of a 19 story, 135 x 200 ft. office building, 8 and 10 story, 150 x 171 ft. warehouse units on Commerce and Kendall Sts. to the Watson Co., 1927 South Akard St., Dallas. Estimated cost $5,000,000.

Ont., Timmins—The Hollinger Consolidated Gold Mines awarded the contract for two 12,500 kva. electrical generators in connection with power development at Island Portage on the Abitibi River to the Canadian Genl. Electric Co., 212 King St., W., Toronto. Estimated cost $250,000. Noted Aug. 7.